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Foreword

The development of facilities and new and important programs for research showed continued progress during 1961. Further moderate expansion of several research programs was made possible by increased funds for fiscal year 1962. These increases have enabled us to add needed personnel in forest management, forest economics, forest insects, forest products utilization, range management, and watershed management research. In addition, a sum of money was set aside for cooperative aid projects with the forest schools of the Pacific Northwest. We believe this provision will assist and encourage forest research and graduate student training at these institutions.

Contract for construction of the Corvallis (Oreg.) laboratory was awarded in the spring, and at the year's end the building was about 50 percent completed. We expect to occupy it by about June 1. In the meantime, we are adding scientists to our staff at Corvallis and planning purchase of scientific equipment. One purchase, an electron microscope, will greatly enlarge the potentialities of our research in many areas.

Funds were appropriated in fiscal year 1962 for construction of a soils and water office-laboratory at Wenatchee, Wash., and a silviculture office-laboratory at Bend, Oreg. Building plans and specifications are now being completed, and we expect to award building contracts this spring. Construction on both structures will start late in the spring or early summer.

A 9-acre tract was acquired from the Veterans Administration at Roseburg, Oreg., this year. When funds are made available, an office-laboratory will be constructed to house our Roseburg Research Center. Negotiations are underway for acquisition of a building site at La Grande, Oreg.

Progress in our program of providing adequate facilities for our scientists and supporting staff and in conduct of our research programs has been greatly expedited by cooperation and advice of many individuals and public and private agencies.

Details of the Station's accomplishments during 1961 and plans for 1962 are set forth in this report.

R. W. Cowlin

ANNUAL REPORT

1961

February 1962

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
R. W. Cowlin, Director Portland, Oregon

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

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Range, Wildlife Habitat, and Recreation Research

In 1961 we continued to orient our program toward more fundamental studies of environmental factors in relation to livestock, wildlife, and people. The vegetation-game management studies being done in cooperation with the Oregon State Game Commission were changed to include more detailed measurements of game forage in relation to deer numbers and migratory habits. Other investigations in Oregon and Washington dealt with the interrelations between big game, livestock, and timber production. Recreation research was started on two wilderness-type areas with emphasis on the activities of wilderness users.

MANAGEMENT OF BIG-GAME RANGES

Forage Utilization by Deer

As part of our continuing cooperative project with the Oregon State Game Commission, 20 mule deer rumen samples were collected by them on the Silver Lake deer summer range in October 1959 for foraging habits and food preference studies. Since the previous report on this facet of the project (see the Station's 1959 Annual Report, p. 33), we have completed classification and description of the vegetation types in the herd range area. Consequently, it is now possible to arrange the results of the rumen sample analyses into natural groupings according to vegetation types.

Major food species, by vegetation type, of the rumen samples according to percentage of total volume and frequency were:

Vegetation type	Food	Percent volume	Percent frequency
Ponderosa pine-bitterbrush-Idaho fescue (10 samples)	Antelope bitterbrush	70	100
	Quaking aspen	10	20
	Sierra juniper	7	30
	Lichens	3	60
Ponderosa pine-white fir-snowbrush ceanothus (4 samples)	Snowbrush ceanothus	42	75
	Forbs	10	75
	Mushrooms	10	100
	Pine manzanita	7	50
	Grass	6	100
	Currant	5	75

Vegetation type--continued	Food	Percent volume	Percent frequency
Ponderosa pine-quaking aspen-big sagebrush (6 samples)	Quaking aspen	28	83
	Lichens	19	67
	Grass	15	100
	Big sagebrush	13	100
	Forbs	9	67

This arrangement points out the need for management of a deer herd and its habitat on an ecological basis. It also shows that species ordinarily considered to be of only moderate value, such as snowbrush ceanothus, pine manzanita, quaking aspen, and big sagebrush, supply important parts of the deer diet in certain vegetation types. Therefore, management of a herd unit must consider each individual part of the total habitat complex instead of considering the total unit as a single entity.

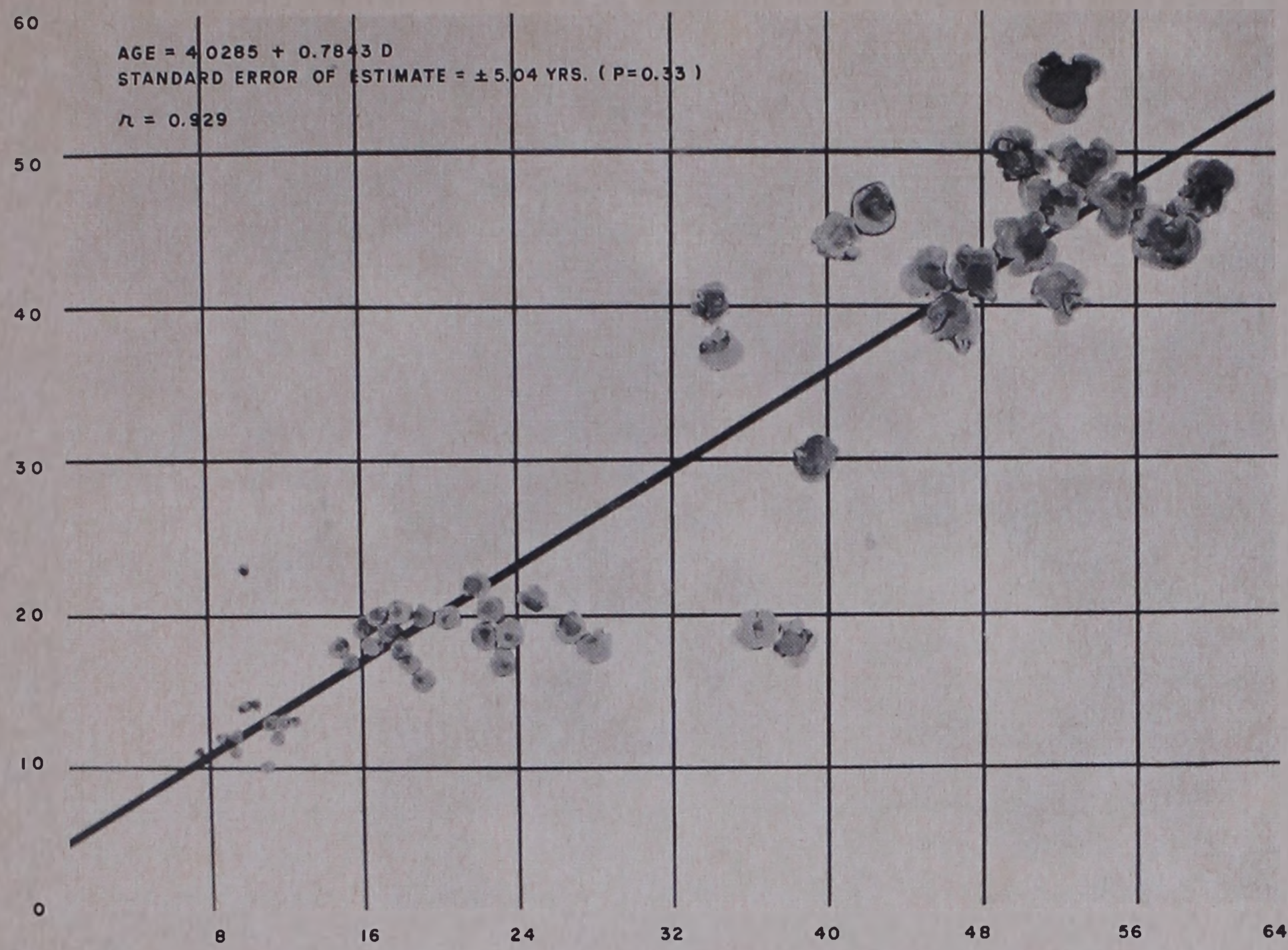
Antelope Bitterbrush Age Prediction

Studies involving descriptions of plant communities as expressions of site potential are often more meaningful if plant ages can be determined. Antelope bitterbrush, a long-lived woody perennial, reveals its age by definite annual rings which may be counted in cross sections of the stems. Because it is often not feasible to destroy plants to determine their ages, we began an investigation of the relation between age and other plant characteristics, some of which are easily measured without harming the plant.

The characteristics we chose to relate to age were (1) area of stem cross section, (2) weight of plant above ground line, (3) volume of an elliptic cylinder formed by extending the perimeter of the plant crown to the ground, computed from the formula, volume = πabh where a and b are semiaxes and h is height, (4) maximum stem diameter at root crown, (5) stem area squared, (6) elliptic cylinder volume squared, and (7) stem area times maximum stem diameter. The last three power and product variables were considered to account for any peculiarities in the relationship of age to area and diameter.

We collected 51 antelope bitterbrush plants between 11 and 54 years of age from a single uniform site and used multiple regression analysis by electronic computer to establish the relation of age to the seven variables listed above.

Multiple regression equations for all possible combinations of the seven variables were solved on the electronic computer. The analysis showed that the relation between age and maximum stem diameter accounted for 86 percent of the total variation among ages. The additional variation accounted for by the six variables other than maximum stem diameter was not significant. Thus, the single variable equation, $Age = 4.0285 + 0.7843D$, where D is maximum stem diameter, is the best one for predicting antelope bitterbrush age on the site sampled.



Regression of age on maximum stem diameter for antelope bitterbrush showing actual stem sections plotted on the scatter diagram.

Big-Game Habitat Problems in Western Oregon

The major portion of our big-game habitat research has been concerned with mule deer and Rocky Mountain elk ranges in eastern Oregon and Washington. An expanded program during the past year allowed us to focus needed attention on Columbian black-tailed deer and Roosevelt elk habitat problems west of the Cascade Range.

A preliminary survey showed that big-game habitat problems in western Oregon can be classified under a single category: integrating big game with forestry. The primary problems deal with deer and elk browsing on coniferous seedlings after timber harvests, wildfires, or other disturbances create openings in otherwise dense forests. These problems are complicated by certain big-game animal habits, forestry practices, and climatic conditions unique to west-side conditions.

The big-game animals are primarily nonmigratory. Only higher elevations on the west slope of the Cascade Range receive sufficient quantity and

duration of snowpack to cause significant mass animal movements. Occasionally, local snow conditions during the winter or drought conditions during the summer cause short-time, short-distance movements.

The "clear-cut" method of timber harvesting west of the Cascades initiates a chain of events contributing to the browsing problem. This method of cutting improves the deer habitat by creating edge effects and improving game forage conditions. This is turn attracts animals to the area. Frequently, the animal buildup is in excess of a desirable forage supply. Consequently, less desirable forages, including tree seedlings, are grazed. Similar events succeed wildfire.

The climate west of the Cascades is such that a seasonal imbalance of forage exists. Long growing seasons with abundant rainfall create long green-feed periods with lush growth. However, additional high rainfall during the nongreen-feed period leaches nutrients from mature plants and drastically reduces their nutritional value. During this nongreen-feed period, coniferous seedling browsing by game is most extensive and severe.

Three specific problem areas need investigation to harmonize big-game–forestry relations: (1) understanding of habitat ecology, (2) development and selection of adapted forages for big game, and (3) foraging habits of deer and elk with emphasis on palatability and nutritional quality of selected species.

High-priority studies in habitat ecology should include classification of undisturbed forests into natural ecological units. In addition, these studies will provide knowledge on land use priorities.

As part of the classification studies, patterns of vegetation succession following logging and/or burning need investigation. Particular emphasis should be placed on defining the sequential changes of preferred big-game forages.

Additional habitat ecology studies must include the competitive interrelations between understory vegetation and forest trees with special emphasis on the relation between tree seedlings and residual vegetation after logging or burning. Two of the most important habitat factors needing study are: (1) moisture requirements of tree seedlings and the more aggressive herbaceous and shrubby species and (2) tolerance of tree seedlings to shade of herbaceous and shrubby plants.

Use of introduced forage plants can help alleviate browsing of coniferous seedlings in three ways: (1) extending the green-feed period into the late fall and early winter, (2) providing palatable forage earlier in the spring than is afforded by native vegetation, and (3) increasing the quantity of palatable forage in areas where native vegetation develops slowly or is in short supply. Studies with introduced game forages must include the productive, nutritional, and palatability performances of selected species to various habitats with and without the use of fertilizers.

Studies of big-game food habits are needed for two purposes: (1) to identify the time and severity of browsing on coniferous seedlings, and (2) to identify species which will supply quantity and quality forages after logging and/or burning. These studies are needed to support the work in habitat ecology and animal food habits.

RANGE-TIMBER RELATIONSHIPS

Methow Pine, Spacing-Growth Increment, and Forage Production Study

Overstocked stands of ponderosa pine reproduction are common throughout much of eastern Washington. In addition to falling far short of timber potential, these areas also produce little forage for game and livestock. With proper management the productive capacity of these areas can be greatly increased for both timber and forage.

In 1959 we established a combination pine, spacing-growth increment, and forage production study in cooperation with the Washington Department of Game and Okanogan National Forest to provide some guidelines for managing these areas. We selected a study area (site IV for pine) near Winthrop, Wash., with a stocking rate of 2,500 to 3,000 pine stems per acre and an average d.b.h. of 2.5 inches. The following pine spacings were established with three replications each in a randomized block experimental design: unthinned, 13- by 13-foot spacing, 18- by 18-foot spacing, and 26- by 26-foot spacing. Table 1 shows the resulting increases in production of understory vegetation three growing seasons after the tree thinning treatments were applied.

Table 1.--Increases in production of air-dried ground vegetation under four intensities of pine spacing 3 years after application of tree thinning treatment

(In pounds per acre)

Class of vegetation	Tree spacing treatment (feet)							
	Unthinned		13 by 13		18 by 18		26 by 26	
	1959	1961	1959	1961	1959	1961	1959	1961
Grasses	47	69	114	177	88	198	93	215
Forbs	68	104	104	181	40	123	42	141
Shrubs	9	7	48	84	15	70	20	63
Total	124	180	266	442	143	391	155	419

Covariance analysis showed that spacing had a significant effect on understory production. The Duncan multiple-range test of treatment differences showed that all spacings differed significantly from the unthinned at the 95-percent level. The 18- by 18-foot and 26- by 26-foot spacings differed significantly from the unthinned at the 99-percent level. None of the spacings was significantly different from any other.

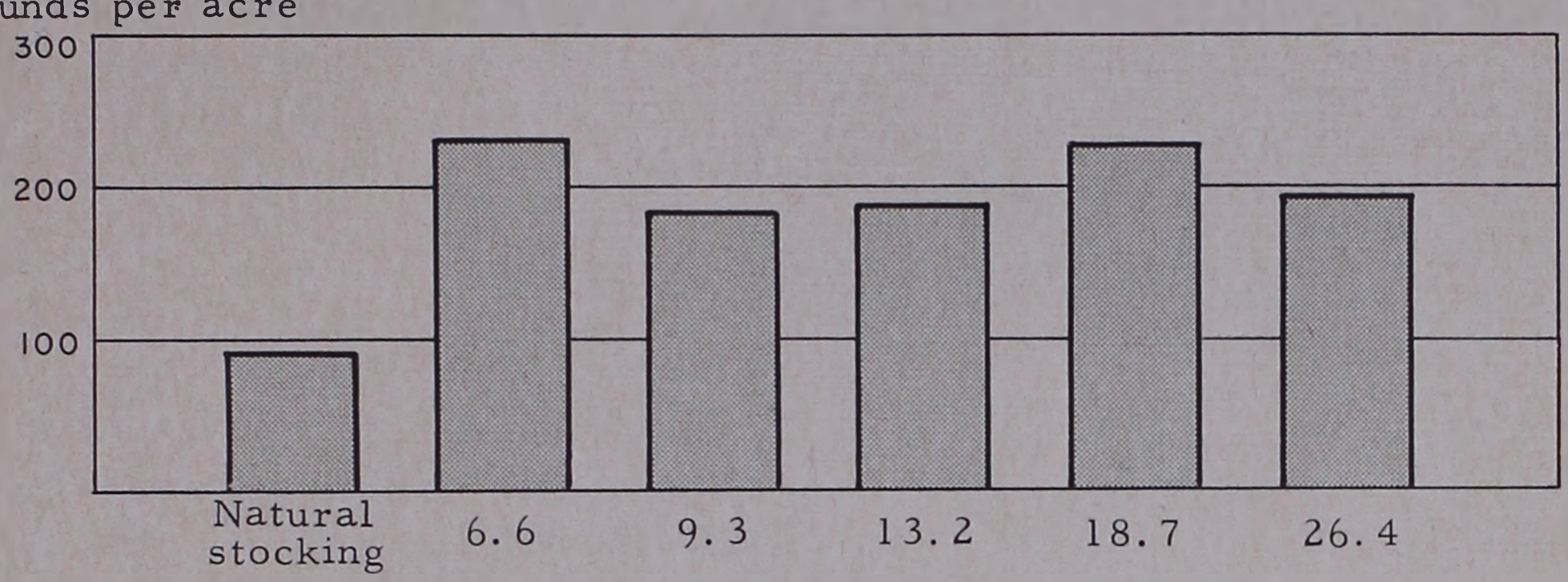
Response of Understory Vegetation to Tree Thinning in Oregon

Cover and production of herbaceous and shrubby vegetation growing under dense, unthinned sapling stands of ponderosa pine and five different spacing levels of similar stands were measured in central Oregon. In addition, bitterbrush samples were collected for chemical analyses of ash, fat, crude protein, crude fiber, and nitrogen-free extract in unthinned stands, stands thinned to an intermediate level (13.2-foot spacing), and stands thinned to the widest level (26.4-foot spacing). This work is being done to: (1) determine any changes in quantity and quality of grazeable game and livestock forage created by thinning these dense stands of reproduction, and (2) to isolate the level of timber stocking commensurate with forage production.

Natural stocking *13.2-foot spacing* *26.4-foot spacing*

Dense, unthinned stands of ponderosa pine saplings have sparse, poor-producing understory vegetation compared to thinned stand.

Our initial data from this long-term study were gathered four growing seasons after thinning. Preliminary results indicate that total crown cover and production of species under thinned stands have increased over 100 percent above natural stocked stands.



Four years after treatment, shrubby and herbaceous vegetation under thinned pine reproduction produced more than twice as much forage as under dense, unthinned stands.

Recovery of Understory Vegetation on Logged-Over Pine Range

Observations on the late stages of herbaceous and shrubby succession following logging of ponderosa pine are nearing completion. Recovery of understory vegetation has been followed for almost 14 years in a study conducted in eastern Oregon.

Quantitatively, the major turning point was restoration of some sort of understory by the fourth year after logging. It was at this time that aggressive forbs reached their maximum development and offset most of the total cover lost through logging disturbance. The forb cover was two-thirds greater than it was initially and gave most of the logged-over areas a "weedy" appearance.

At the halfway point in the study's duration, the forbs continued to be an abnormal component of the understory. They were 59 percent above their original cover with lupine remaining most prominent of the group, whereas grasses and shrubs were still a little less than their initial cover.

First results from the final round of observations indicate a fairly well-balanced recovery of understory vegetation in 14 years on areas which were only

There are no pine seedlings or saplings of 1 to 15 years of age on this old skidtrail except beside the down snag and in a small patch of debris just beyond the snag and to the right of witness staff. The easily discernible forbs in the foreground are lupine. About four tufts of elk sedge are also present in the foreground but inconspicuous.

lightly to moderately disturbed by logging. Yet, on the heavily used skidtrails recovery of vegetation is strikingly retarded. In the spring of the year, some annual forbs add to the scanty cover provided by occasional clumps of lupine and tufts of sedge. In other areas, skidtrails are the scene of invasion by noxious or highly flammable plants.

One of the most unfortunate developments on skidtrails 14 years after logging was the infrequency of ponderosa pine seedlings. Those few seedlings found were alongside down snags or in logging debris or other litter accumulation. Transect data show that pine seedlings occurred on more plots disturbed by logging and rodents than on undisturbed sample plots:

Condition of soil surface	Sample plots with seedlings (percent)
No disturbance	3.75
Current slash or old debris	3.75
Rodent workings	1.25
Skidding plus rodent workings	1.25
Light skidding	6.25
Skidding plus slash	6.25
Skidding plus old debris	3.75
Skidding only	1.25
Total	27.50

No seedlings survived to the seventh year on heavily skidded trails except where site conditions were probably ameliorated by slash or some sort of forest debris. By the 14th year, some additional mortality had occurred among pine seedlings but appeared unrelated to soil conditions on sample plots.

Deterioration of soil structure by traffic compaction, absence of humus, nd lack of a "nurse crop" are suspected causes for failure of natural pine regen- ration to survive on barren skidtrails. These same adverse factors are also a andicap to revegetation of skidtrails by native grasses and sedges. Furthermore, negrass and elk sedge are notably poor seed producers; and without an abundant eed source, they are unable to restore heavily skidded trails to prelogging con- tions in 14 years.

Slowness of secondary plant succession in restoration of watershed, mber, wildlife, and range values points to a need for mechanical and vegeta- onal measures in rehabilitating logged-over pine lands in the Northwest.

MANAGEMENT OF LIVESTOCK RANGES

eather and Forage Conditions

On Blue Mountain summer range, both native forage production and uality were curtailed by adverse weather. Here, spring precipitation was only bout 70 percent of normal, and no rainfall effective for growth occurred after id-June. In spite of several August and September rains, fall regrowth of the emidormant forage plants did not begin until early October.

ystems of Management and Summer Cattle Gains

Weight gains by cows and calves in the 7-year-old cattle management tudy at Starkey were quite variable in 1961. This year, cow gains were slightly elow those of the dry 1957 and 1959 seasons. Calf gains were better than those n 1959, yet below those made during 1957.

There was no significant difference between gains made under deferred- otation and season-long systems (table 2). Neither were gain differences be- ween grazing intensities (stocking level) consistently large. Under Blue Moun- ain conditions, it appears that during normal and good forage years weight gains espond uniformly to treatment, but in fair or poor grazing seasons gains are sually erratic and variable under treatment.

The 1961 forage conditions produced some unusual, but not statistically neaningful, cattle responses. For the first time in 7 years of treatment, calves nder the deferred-rotation system outgained those under season-long grazing. Of the 12 ranges grazed under the two systems (six deferred-rotation and six eason-long), the deferred-rotation calves outgained their season-long counter- arts in five out of the six paired treatments.

Cow gains at the moderate stocking level were materially heavier than hose at the light stocking rate in both deferred-rotation and season-long systems. Cows showed relatively good gains under deferred-rotation light grazing but poor gains at the heavy level in relation to season-long management. In past years,

this interacting trend has only appeared in one of the two experimental blocks or ranges.

Table 2.--Summer weight gains of cows and calves on forested mountain range[1/]

(In pounds)

Grazing level[2/]	Cows			Calves		
	Deferred-rotation	Season-long	Average	Deferred-rotation	Season-long	Average
Light	14	10	12	202	190	196
Moderate	28	28	28	186	158	172
Heavy	-25	15	-5	163	158	161
Average	6	18	12	184	169	176

[1/] Summer grazing season of 4 months began June 8, 1961.

[2/] Stocking rates of light, moderate, and heavy correspond to 10, 7.5, and 5 acres per animal-unit-month, respectively.

Fall Response After Heavy Stocking

Condition of the cattle in 2 of the 12 Starkey experimental ranges became a problem in 1961 and necessitated the first change in stocking during the history of the study. Cumulative effects of excessive grazing became apparent in late season. Early removal of cattle from the two heavily grazed pastures of the north block was prompted by (1) weakened range following 8 years of excessive harvest and (2) the general shortage in the current forage crop.

After midseason, it became evident that cattle from these two ranges were rapidly losing weight and showing signs of unthriftiness. Three weeks before season's end, the cattle from the deferred-rotation and season-long heavy-rate ranges were gathered and weighed. They were then grazed on a previously unused auxiliary range. At the end of the regular season, they were again weighed to determine whether weight or thrift recovery had taken place.

For the summer period, cows of both heavy treatments lost weight; losses by deferred-rotation grazed stock being the greater. Calf gains were mediocre, but again, those under the season-long treatment performed the best. Initial weights of the cows and calves were approximately the same under both treatments.

After the cattle were combined and grazed under light stocking, the trends in weight response between systems of management reversed. Cattle previously under the season-long system performed the poorest, particularly the cows.

A possible explanation for the reversal may be that deferred-rotation cattle, having been rotated to similar ungrazed dry forage 2 months previously, were better adapted to the new forage conditions. On the other hand, this late-season change of pastures was the first shift for cattle grazed season-long, and for some reason they did not respond during the late period when placed in an ungrazed pasture.

Late-Season Weight Gains of Cows and Calves

An investigation of the value of Blue Mountain summer range for producing late-season cattle weight gains was first initiated in 1961. Previous studies have shown good gains for all classes of cattle during the green-feed period (June through mid-August) but only fair to poor gains for the remainder of the grazing season, from mid-August through October (table 3).

Table 3.--Fall weight changes of cattle grazed on summer range under excessive stocking

(In pounds per day)

Grazing treatment	Cows		Calves	
	Deferred-rotation	Season-long	Deferred-rotation	Season-long
Summer, heavy (June 8 to September 8)	-0.37	-0.02	1.41	1.47
Fall, light (September 8 to September 28)	-.43	-1.45	.91	.81

During the midseason roundup, 10 pairs of commercial-type Hereford cows and calves were selected for uniformity in age and weight. Initial weights were taken August 17, and successive weights were recorded at about 14-day intervals.

The bunchgrass range, on which these fall-weight cattle grazed, was gently rolling, mountain grassland with occasional forested draws and slopes. The intensity of grazing was light with an abundance of ungrazed forage always available.

Initial cow weights averaged 918 pounds and their calves 323 pounds. Cows showed a net loss of 1-1/2 pounds during the first 14-day period; thereafter, they lost weight at progressively more rapid rates until mid-October. The weight change for calves declined from a 1.7-pound-per-day rate of gain, initially, to a slight weight loss in early October. Downward trends in cattle weights and gains may have occurred as much as 2 weeks earlier than usual because of forage conditions this year.

Some time during mid-October, a dramatic change in feeding conditions took place and both cows and calves showed gains. Studies of nutrient quality have shown that forage plants on these ranges become deficient in protein by about mid-July. The steady decline in cattle weights after midseason can, in part, be explained by the diminishing forage nutrients. The abrupt shift from weight loss to gain during late October reflected the fall greenup of certain forage species resulting from the first effective fall rains which began in early October. The time of this regrowth varies from year to year.

ECOLOGY AND PHYSIOLOGY

Vegetation-Soil Relations

We completed classification of the vegetational, soil, and topographic components of nine ecosystems in the central Oregon juniper zone. This classification was based on ecological units relatively undisturbed by man or grazing animals.

We found that the vegetation of specific ecosystems in the central Oregon juniper zone is not always associated with individual taxonomic soil units. This is true particularly when dealing with zonal soils--soils with relatively mature profile characteristics expressing longtime environmental interactions. In these cases, cause and effect relations between the vegetation and soil of an ecosystem were more readily discerned when probable compensatory effects of various soil factors were considered in field examinations.

For example, different stands of one plant community were supported by different soils representing two series. Both of these soils had loam surface horizons, but their respective parent materials and other profile characteristics were quite different. One soil had developed from river- and lake-laid sediments containing small basalt fragments and had a discontinuous caliche. This soil had a claypan 9 inches thick located 15 inches below the soil surface. The other soil had developed from loess and very fine sands. It also had a claypan, but this restrictive layer was only 2 inches thick and began 8 inches below the soil surface.

No roots penetrated deeply into the thick claypan of the first soil. Even though the claypan of the second soil was closer to the surface, the thinness of this horizon allowed some roots to penetrate into the underlying loose material. In this soil zone the plants developed normal root systems and used moisture and nutrients that otherwise would have been unavailable. As a result of these

ompensating factors, both soils supported essentially similar plant communi-
.es.

[abitat Requirements of Antelope Bitterbrush

A study completed this year shows that the occurrence of antelope bitter-
rush in the central Oregon juniper zone is closely associated with certain soil
nd topographic characteristics.
Soil characteristics controlling
he amount of bitterbrush in
pecific habitats include: (1)
ature of the underlying material,
2) texture of the subsoil, (3)
tructure of the subsoil,
4) stoniness of the solum, and
5) depth of the solum. Slope
spect appears to be the only
opographic characteristic lim-
ting the development of the
species.

In near-pristine habitats,
bitterbrush stands have achieved
heir greatest development on
Zonal Brown loam soils derived
rom mixed andesitic-rhyolitic
colluvium on southeast slopes.
The underlying material is
cracked and loose, allowing
deep root penetration. The sub-
soil is a heavy-textured clay or
clay loam with strong angular
blocky structure. These heavy-
texture and strong-structure
characteristics are offset by a
large proportion of stones in
the soil, 50 percent by volume.
Soil depth is relatively shallow,
20 inches, but is compensated
by the cracked, loose nature of
of the underlying material
which has thin films of soil on
the faces of the stones.

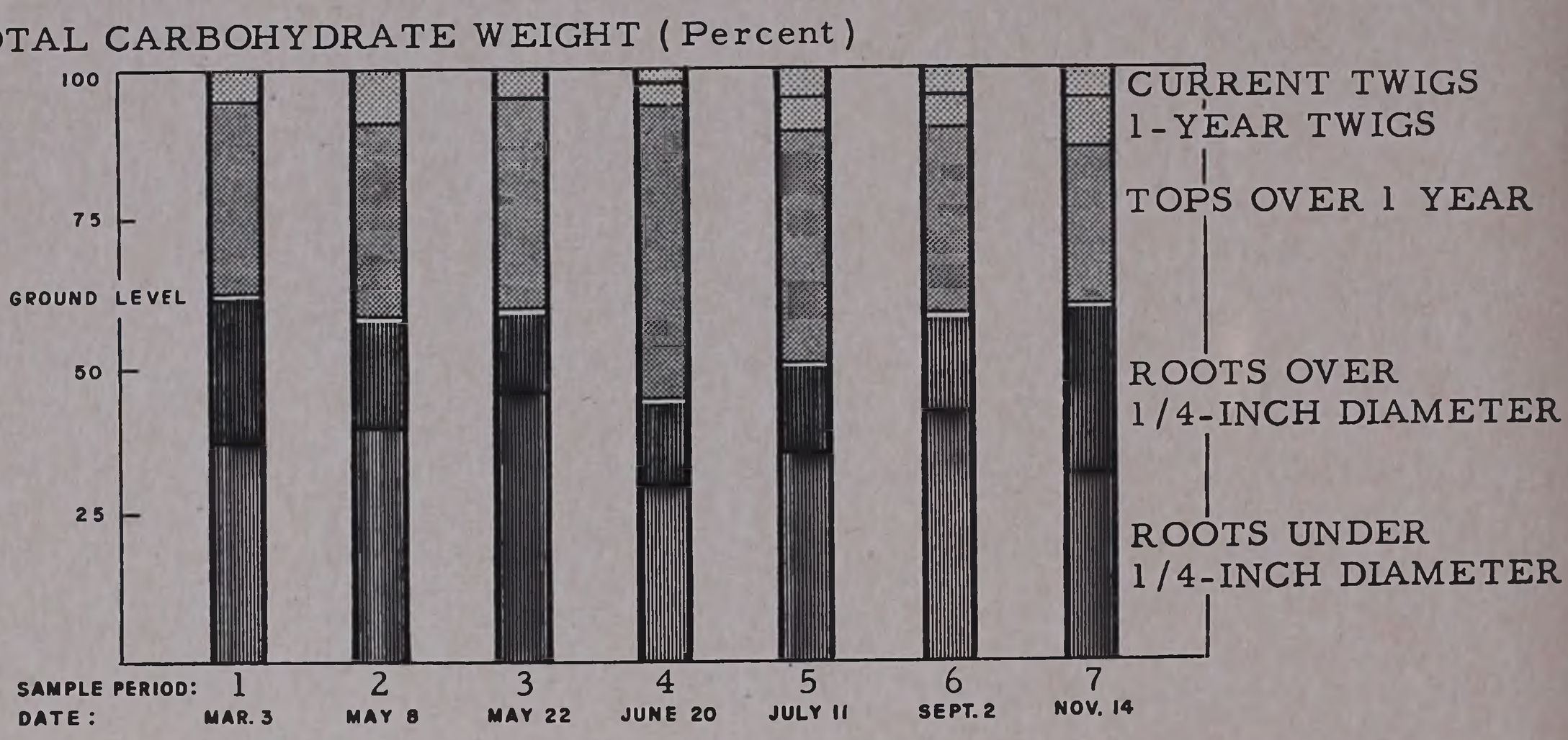
Bitterbrush grows well in A, where the clayey subsoil is made more "porous" by stones. The absence of stones in the clayey subsoil of B inhibits growth of the species. Other habitat factors are approximately the same.

The amount of antelope bitterbrush decreases as the result of the combined effects of lessened soil depth, finer soil texture, stronger structural development, decreasing soil stoniness, increasing impermeability of

the underlying strata, and changing slope aspect to north or south. No single habitat factor measured appears to limit occurrence of the species.

Carbohydrate Accumulations in Antelope Bitterbrush

We completed a study of carbohydrate reserves in bitterbrush as part of continuing research on the ecology of this important browse species. Seasonal fluctuations in total available carbohydrates expressed as a percentage of air-dry sample weight were presented in last year's report. However, evaluation of plant food reserves on the basis of percentage composition alone is sometimes less informative than when considered in terms of absolute amount or weight. Consequently, some additional data are presented to show the proportions of total available carbohydrate weight stored in different parts of the plant throughout the growing season. The various sampling periods were established to coincide with the following stages of plant development: (1) spring dormancy, (2) full leaf, (3) full flower, (4) the period of rapid twig growth and early seed formation, i.e., the grand growth period, (5) seed maturity, (6) cessation of growth, and (7) leaf fall.



Proportion of total carbohydrate weight occurring in certain parts of antelope bitterbrush.

TECHNIQUE STUDIES

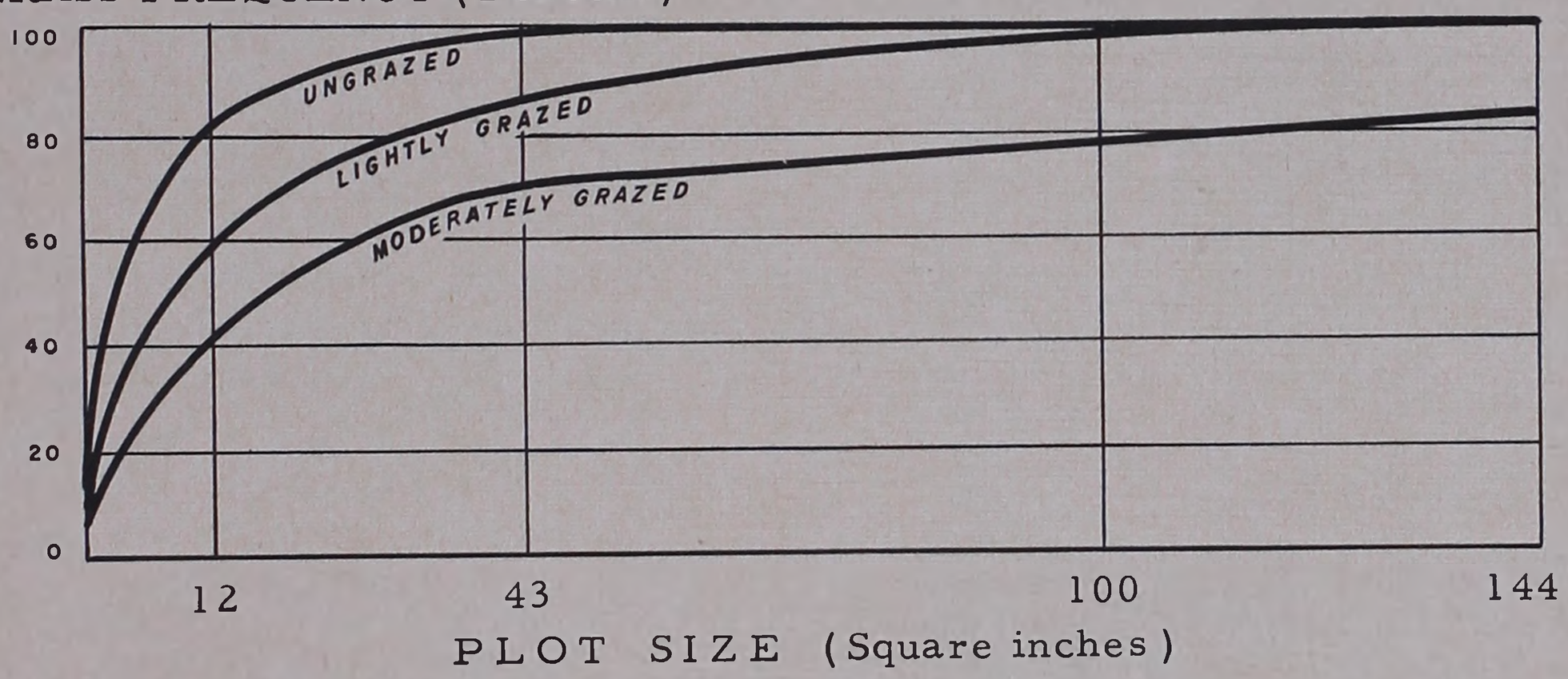
Vegetation Measurements

In eastern Oregon, a new measurement technique study was undertaken to improve inventory work for studies of soil-vegetation relationships. Initial work has centered on determining an optimum plot size to obtain relative values of species frequency. Such data, when combined with other vegetation characteristics such as cover and weight, will be valuable in (1) comparing the successional status of the major soil-site communities, (2) evaluating the effects of grazing, and (3) measuring the trend in range condition in these communities in the central Blue Mountains area.

Distance measurements were used to obtain an array of the potential mean area (reciprocal of density) of the five most abundant, dominant, and important forage species on seven major soil-site units long protected from livestock grazing. The optimum plot size was then determined as that size which would include the first 85 percent of the mean areas of the dominant or codominant species.

It was found that optimum plot sizes ranged from approximately 12 square inches for pinegrass on forested soils of the Tolo series to 80 square inches for bluebunch wheatgrass on the grassland soils of the Ukiah and Albee series. Optimum plot size on soil-sites supporting dominant Sandberg bluegrass and onespike danthonia was 41 square inches. On Klicker soils, where elk sedge was the dominant, optimum plot size was 55 square inches.

Similar measurements were made in 10 adjacent communities grazed by cattle. Frequency comparisons showed those derived from the optimum plot



Relation of pinegrass frequency and plot size in the Douglas-fir, ponderosa pine, pinegrass type under different degrees of grazing intensity.

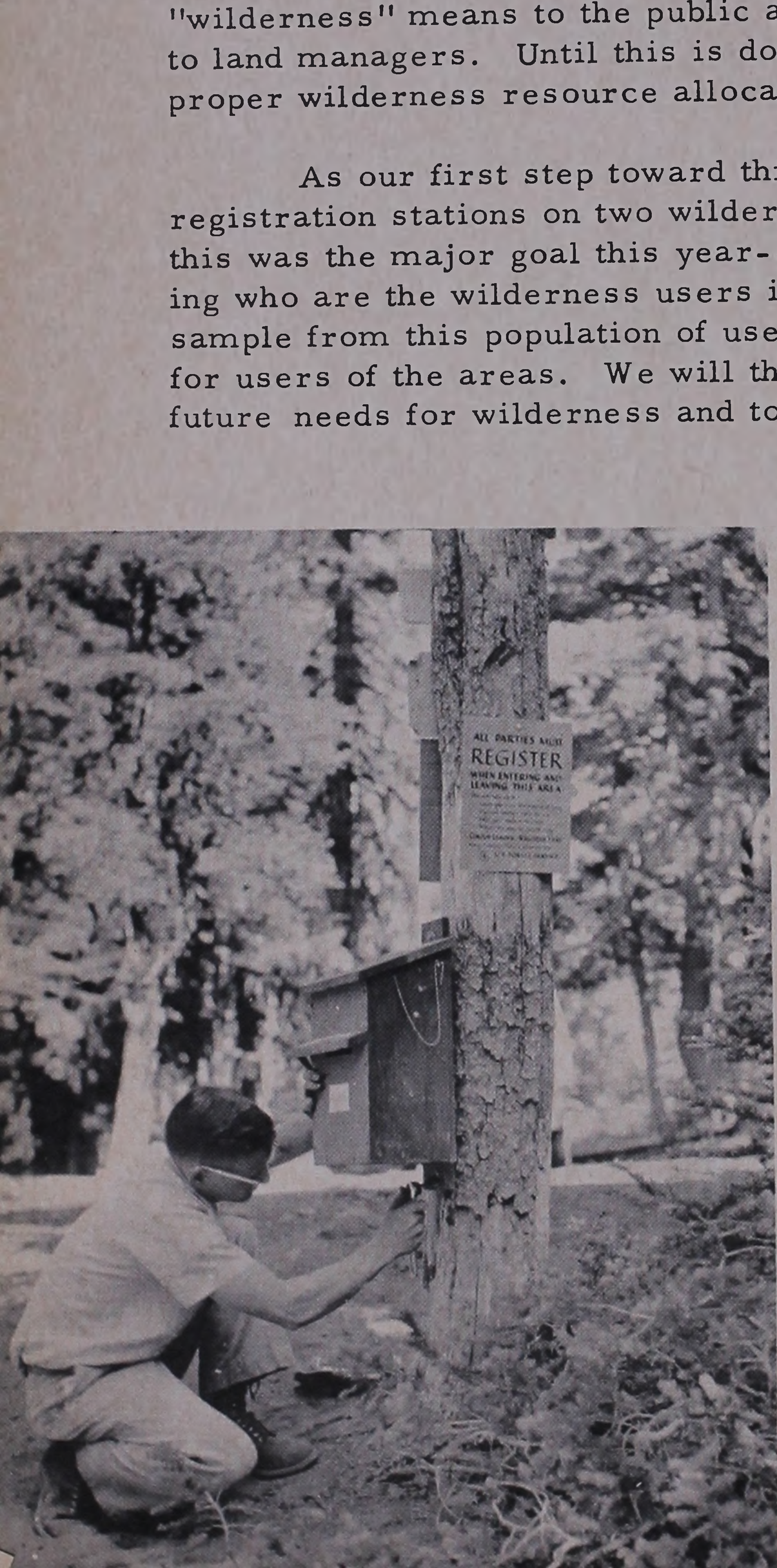
sizes were more realistic in showing differences in species values as a result of grazing than did frequency values derived from smaller or larger plots. However, the data indicate that a plot 40 square inches in size would be adequate for frequency determination of all soil-site communities, thus allowing direct comparison of frequency data from all soil-site communities.

RECREATION RESEARCH

Needs, allocation, and management of wildland resources for wilderness recreation remain of paramount concern to us in recreation research. We have concentrated this year on development and evaluation of a method for gathering basic back-country wilderness-use information.

One of our major needs in wilderness research is to determine what "wilderness" means to the public and to define this concept in terms meaningful to land managers. Until this is done, we cannot have a clear objective for either proper wilderness resource allocation or proper wilderness management.

As our first step toward this definition, we installed a study of unmanned registration stations on two wilderness-type areas in the region. We hope--and this was the major goal this year--to develop a method for adequately determining who are the wilderness users in the Pacific Northwest. We can scientifically sample from this population of users for intensive study of what wilderness means for users of the areas. We will then undertake studies to evaluate present and future needs for wilderness and to determine how to allocate and manage lands to most effectively satisfy wilderness needs in harmony with other needs for land.



Unmanned registration stations were installed along 52 access trails into two wilderness-type areas in Oregon.

We also tested registration stations as a method for accurately determining amount and character of wilderness use. This information is needed immediately by local land managers in order to more effectively enhance recreation and protect the resources of the areas for future use. Their tasks include trail signing and other interpretive services, trail work, camp area maintenance, and fire prevention.

In this year's study of unmanned registration stations we placed stations at 52 takeoff points for trails into the wilderness-type areas. With the stations we tested two registration methods and three response-eliciting sign wordings. We wished to know if the method of registration and the tone of sign wording have an important effect on data obtained. On randomly selected days and trails, we had interviewers up trails well beyond the stations; consequently, we have a check on the accuracy of the registration data at each type of station. We also kept a record of vandalism at each station. And the study was made from May 30 through November 15 so that all classes of recreationists who use the areas were encountered. Although the information gathered about the effectiveness of the system is still being analyzed, some general conclusions are now possible.

The "typical," or most frequently encountered, 1961 user of the Three Sisters Wilderness Area, Mountain Lakes Wild Area, and unroaded land contiguous to these two Oregon areas may be characterized as follows:

1. He (or she) was walking.
2. He was in a group of from two to five persons.
3. He either lives in Oregon or was accompanied by an Oregonian acquaintance.

A substantial number of the users of each area live in or were accompanied by a resident of some Oregon community less than 100 miles from the area. Also, we know that a large number of the users of the Three Sisters Wilderness Area went into the area only for a day trip.

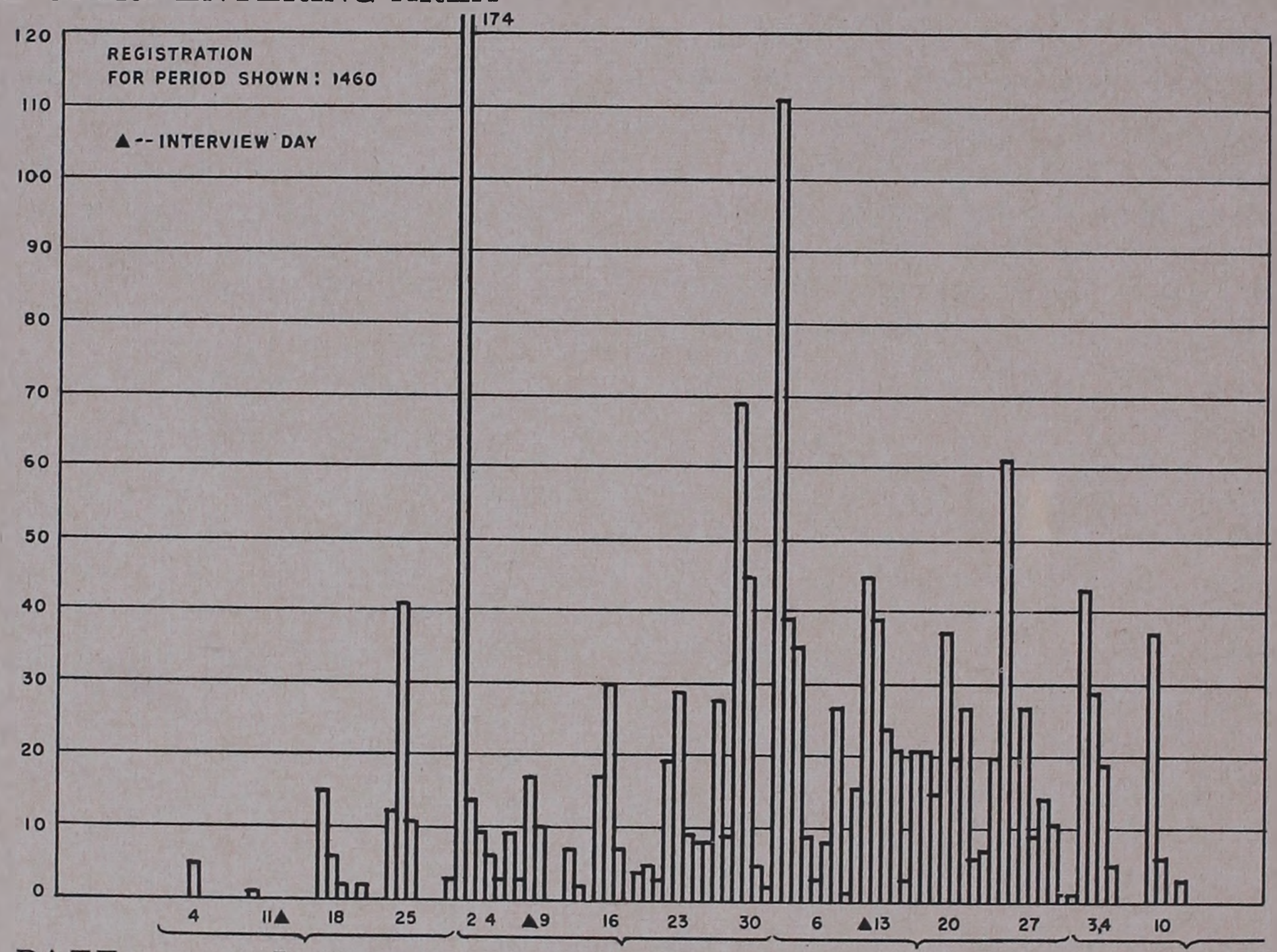
Many wilderness users are cooperative signers at unmanned registration stations. However, we did fail to obtain the cooperation of the bulk of one entire class of users--elk hunters. Of the several thousand groups registered, only a minute percentage wrote other than constructive comments on the registration sheets or cards. Vandalism and animal damage to stations was insignificant, and when vandalism did occur, it usually occurred on the same few trails.

The coverage of all access trails into wilderness areas is difficult to accomplish. Numerous "shortcut" trails exist which are known only to persons intimately familiar with the areas. Sparsely wooded areas of gentle topography which permit a random and dispersed access pattern require considerable ingenuity in placement of stations. To obtain cooperation of horseback parties, stations should be located at a place where riders may sign before mounting. Clearly, choice of station locations is a major factor in the success of an unmanned registration system.

Stations must be conspicuous to trail users. Also, they should be visible for some distance up a trail. It isn't advocated that stations be disharmonious with the natural environment, and it is essential they be placed far enough off the trail to permit easy passage by loaded pack animals. But many persons day-dream or stare fixedly at the ground in front of them as they walk and easily miss seeing an inconspicuous station. Also, near the end of the season, we became aware in interviews that many repeat visitors do not read the signs requesting registration after they have once done so in a season. For signs to be effective, then, it may be necessary to phrase the entire message so it makes an impact in a glance.

Another major factor in the success of such a system is the procedure of expanding registration information to arrive at total use figures. Expansion factors were based on sample comparisons of actual and registered use obtained by interviewers. We discovered use to be extremely variable between trails and even between days on the same trails as shown in the graphs.

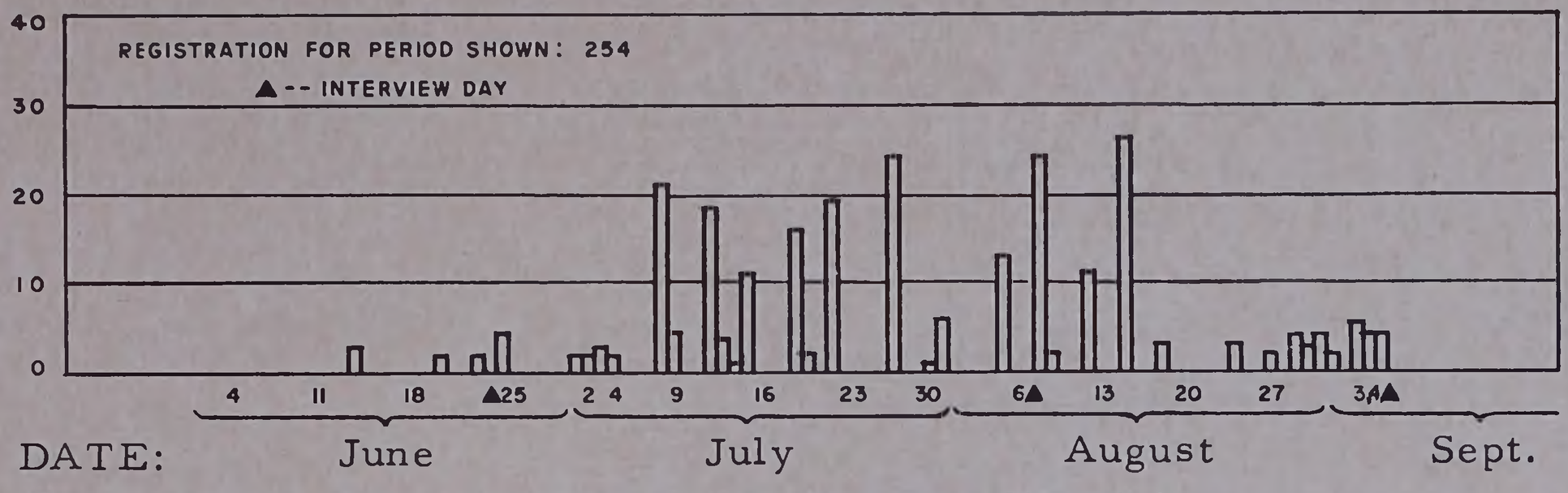
TRAIL USERS ENTERING AREA



(Sundays, holidays, and interview days are listed.)

Registered visits into the Three Sisters Wilderness Area via Obsidian Trail for each day of the 1961 summer season.

TRAIL USERS ENTERING AREA



(Sundays, holidays, and interview days are listed.)

Registered visits into the Mountain Lakes Wild Area via Varney Creek Trail for each day of the 1961 summer season.

Class of use was also highly variable between trails. Interviewers frequently did not encounter persons on lightly to moderately used trails, and as a result a few trails yielded most of the calibration data to be applied to all trails. Consequently, the likelihood of distorted adjustments becomes a troublesome factor.

It seems essential to future success of the system that interviewer assignments be based on stratification of trails by class and intensity of use. It also seems necessary to supplement interviews with trip cameras or perfected pneumatic or electric counters placed on lightly to moderately used trails. Followup of license plate information of vehicles parked at trailheads is another possible way of gathering supplementary calibration data.

Unmanned registration stations seem to have much potential for obtaining vitally needed basic data on wilderness use. But they must be used with care if they are to fulfill their purposes for immediate management and for research upon which to base future planning and management.

PLANS FOR 1962

We will place emphasis on completion and reporting of past and current studies dealing with range and wildlife-habitat relations; give increased attention to ecological and physiological studies of forage plants used by big game and livestock; and plan and start an intensive study of the present needs for back-country wilderness recreation in the Pacific Northwest. Some specific tasks include:

- Formulate new designs for grazing studies to be made after completion of the current management studies on the Starkey Experimental Forest and Range.

- Plan and initiate ecological and physiological studies of principal forage plants on summer ranges in eastern Oregon and Washington.

- Activate the Silver Lake deer enclosure study, in cooperation with the Oregon State Game Commission, to measure and evaluate factors affecting winter foraging habits of mule deer.

- Continue studies of relations between bitterbrush and site factors on different soil types in Oregon and Washington.

- Continue sampling plant communities to determine the effect of grazing on the phytosociological behavior of species that characterize ponderosa pine ranges.

- Complete analysis of the 1961 wilderness-use study and publish the results.

- Plan and start a study of the meaningfulness of wilderness-type recreation experiences associated with large trees in roadside virgin forests of the Pacific Northwest.

- Assimilate the results of the Outdoor Recreation Resources Review Commission study into the Station's recreation research framework.

Watershed Management Research

Several important steps were taken in 1961 to intensify investigations in watershed management research. Our technical staff was increased to eight people by the addition of three specialists: a soil scientist, a meteorologist, and a plant physiologist. Watershed research projects in Oregon, formerly conducted at three localities, have been concentrated in Corvallis. Work in Washington continues to be centered in Wenatchee, where we soon will have a forest soil and hydrology laboratory. Planning for this facility occupied much of our attention during the past year.

In line with these developments, we have given increasing attention to the job of planning more basic research. Emphasis will be given to study of results we observe in experimental plots and watersheds. Only with a knowledge of fundamental processes will we be able to apply management in an intelligent way to highly variable soil, topographic, and cover conditions found in forest and range watersheds.

Our research program, however, is still predominantly in the category of applied research. Progress has been largely the result of field studies to determine how forest cover is related to streamflow and how land use affects erosion and sedimentation. Some of the results learned in 1961 are described in the following report.

FOREST COVER AND STREAMFLOW

Experimental watersheds continue to be the most direct method of learning what happens to water and soil when timber is cut and roads are built. At the H. J. Andrews Experimental Forest we have been obtaining information on precipitation and streamflow from three matched drainages since 1952. More recently, we have obtained information on water quality and temperature, soil moisture use, and rainfall interception. Except for roads constructed in watershed 3 in 1959, the areas have remained undisturbed during the period of observation. All three experimental drainages have a cover of old-growth Douglas-fir and are very similar in all respects.

Low Flows

During three low-water seasons since road construction on watershed 3 (250 acres), we find that late-summer streamflow has been increased. Road construction cleared approximately 8 percent of the total area of the watershed. For 6 years prior to construction, streamflow on the three experimental watersheds proved to be highly correlated. This relationship enabled us to estimate volume and fluctuation of runoff in one watershed from the behavior of a companion

drainage. Thus, after road construction, we have been able to estimate what runoff from watershed 3 would have been if the roads had not been built. Since construction, actual low flow from watershed 3 exceeded estimated flow we would have expected without roads--by 19.3 percent in 1959, 12.4 percent in 1960, and 12.8 percent in 1961. During this same period, watershed 1, another undisturbed watershed, has shown no consistent change in comparison with watershed 2.

Peak Flows

Two large storms in November 1960 and February 1961, which produced 58 and 72 cubic feet per second per square mile, respectively, verified earlier results. The peak flows from watershed 3 showed no increase over that we would have estimated on the basis of correlations established before road construction. Plans have been completed to clear cut an additional 25 percent of the timber in watershed 3, starting early in the summer of 1962. Since Forest Service cutting rarely exceeds this intensity in any one drainage, changes observed should be applicable to large areas on the west slope of the Cascade Range.

Similar experimental watersheds are providing streamflow information on the east side of the Cascades where we have three experimental watersheds in the Entiat River drainage. Measurements indicate that the small lower tributaries of river systems on the east side of the Cascade Range may provide a more significant portion of the total water yield than we had thought. Flow of all three gaged watersheds was well sustained during the past relatively dry summer (table 4). Burns Creek, the largest of the three watersheds, has by far the highest peak flow; but Fox Creek, with the smallest drainage area, maintains the highest minimum flow. More complete inventories of the climatic, physiographic, and vegetative characteristics of these watersheds, along with additional fundamental research, are required before we can adequately explain observed differences in streamflow.

Table 4.--Extreme flows of the Entiat experimental watersheds,

1961 water year

(In cubic feet per second per square mile)

Watershed	Area (sq. mi.)	Peak flow	Low flow	Maximum diurnal fluctuation
Fox Creek	1.65	2.88	0.421	0.067
Burns Creek	2.22	3.25	.340	.033
McCree Creek	2.17	2.04	.177	.059

We are also interested in the rather large diurnal fluctuation in streamflow that occurs during summer months (table 4). Each day, flow drops appreciably, as a result of increased use of water by streambank vegetation, followed by replenishment during the night.

Interception of Rainfall

Why there is a change, or lack of change, in streamflow when vegetative cover is altered could be more readily explained if we knew enough about the principal elements of the hydrologic cycle. Interception is an important part of this cycle. When forests cover the land, some rain is caught by the aboveground parts of the trees. Water that fails to penetrate the crown canopy is caught on the leaves and stems, and most of it is evaporated back into the atmosphere.

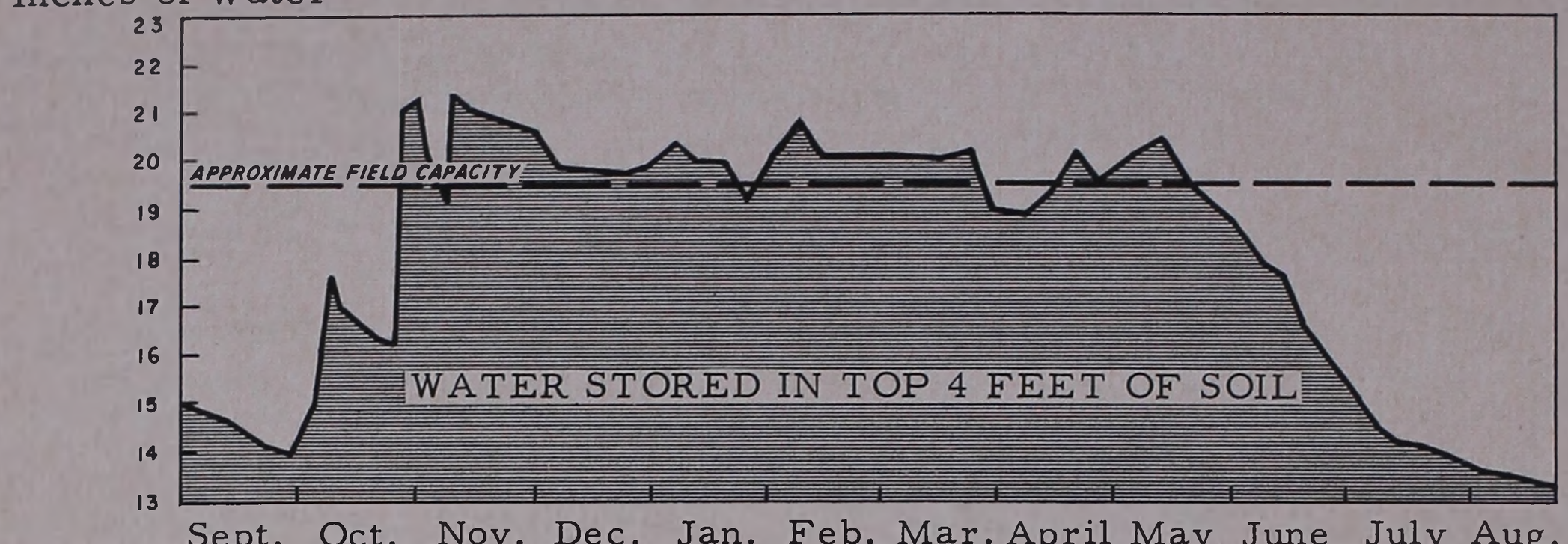
At H. J. Andrews Experimental Forest, our studies in virgin Douglas-fir stands show that an average of 24 percent of the total rainfall does not reach the ground during summer storms. This proportion, however, varies with storm size and time of year. Almost all rain is intercepted in small summer storms of 0.05 inch or less, but the percent of rainfall intercepted is almost negligible during long winter storms, some of which may exceed 4 to 6 inches per day. A mathematical relationship exists between storm size and interception, permitting us to estimate summer rainfall that will penetrate the canopy and reach the soil.

Soil Moisture

Soils in many parts of the Oregon Cascades are capable of storing vast quantities of water. Most of these soils are formed from recently deposited igneous materials, and the profusion of volcanic ash and pumicelike material results in unusually low weight per unit volume. Surface-soil volume weights are near normal for forest soils of the region, averaging 0.9 gram per cubic centimeter. At 3 feet, however, our measurements show volume weights averaging 1.04 grams per cubic centimeter, much lower than would be expected from soils derived from other types of parent rock.

Relatively low volume weights indicate greater soil porosity and, hence, more storage capacity. Using volume-weight data, we can determine storage capacity for given depths of soil in terms of equivalent inches of precipitation.

Water contained in the top 4 feet of soil under mature Douglas-fir forests varies considerably with season of the year. Available storage capacity increases rapidly beginning in mid-May, when trees start to grow and use water. During the first 45 days of 1961, water removed from the top 4 feet of soil in watershed 3 of the H. J. Andrews Experimental Forest averaged 0.1 inch per day. This rate dropped to 0.02 inch per day as the reservoir of available water dwindled. Moisture content of samples taken to a depth of 9 feet suggests that a considerable part of the water used by vegetation during late summer comes from soil depths below 4 feet.

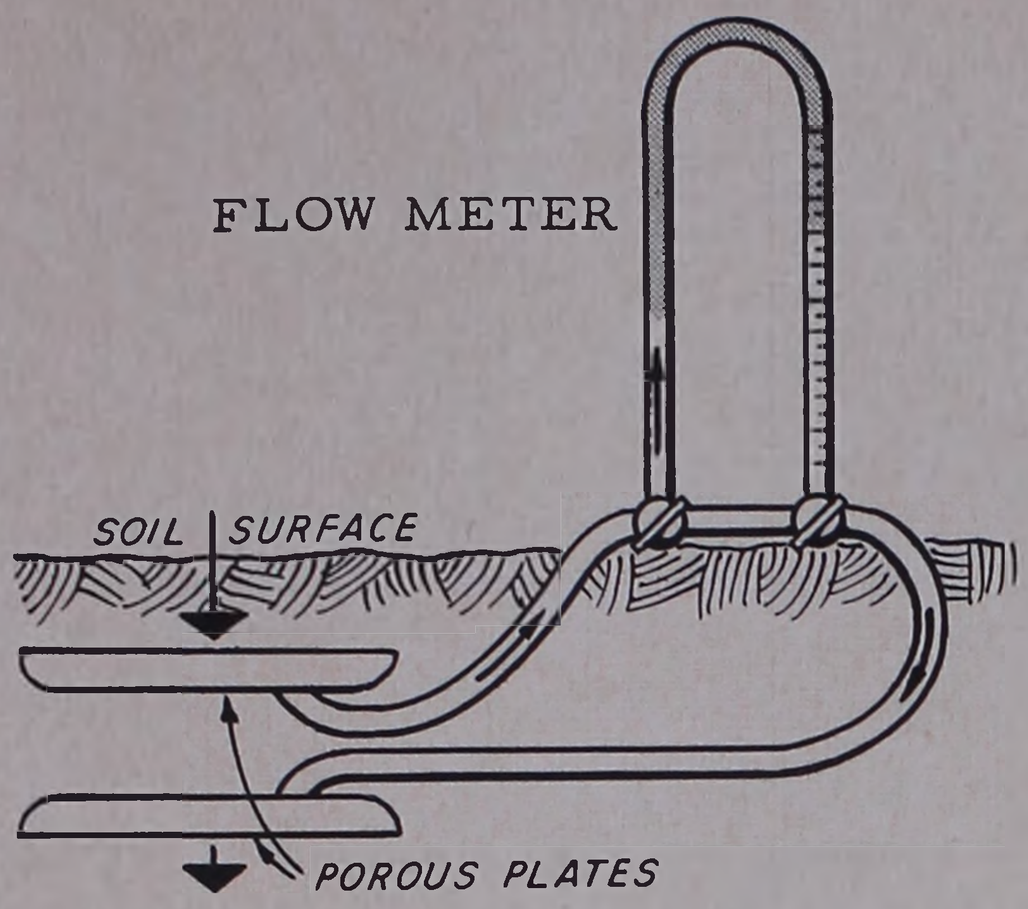


Under old-growth Douglas-fir, water stored in the top 4 feet of soil may range from 1-1/2 inches above approximate field capacity to 6 inches below field capacity at the end of the growing season.

By the end of the growing season, soil storage to a depth of 4 feet is available for about 6 inches of precipitation. Fall rains refill this storage reservoir but some additional temporary storage is usually available. The ability of forest soils to detain water by temporary storage may help to reduce a storm peak by delaying runoff. During winter and early spring in the top 4 feet of soil, this detention-storage capacity may reach 1.5 inches after a prolonged rainless period but averages less than 1 inch. Temporary storage can exercise some control over storm peaks, but can do little to prevent serious floods when several inches of rain fall during a 2-day period.

Soil Water Movement

Water leaves our watershed lands rapidly, but surface runoff is seldom seen on forested lands west of the Cascade summit. We need to know more about how water moves through soils during storm periods. We are particularly interested in the carrying capacity of various soil layers and variation among different soil types. An instrument to study soil water movement has been constructed, consisting of two parts: a displacement flow meter and two porous plates, each sheathed with a rubber cover on one side. In operation, there is a continuous water column from the top plate surface through the meter and to the lower plate surface. A small quantity of water entering the upper plate moves through the meter to the lower plate and returns to the soil. Readings from the meter indicate the rate of flow of water through wet soil. Our first efforts have been devoted to perfecting the instrument; no data on soil water movement are available yet.



Porous plates can be used to measure the movement of water through soil under wet conditions.

Solar Radiation

The quantity of water available for streamflow and subsequent use downstream is equal to the total precipitation minus several losses. The major losses are evaporation and transpiration by the plants. These processes require energy, all of which is derived ultimately from the sun. Snowmelt is also controlled by the sun's energy. Most of this solar energy is received in the form of direct radiation on the site. The quantity of energy available (insolation) depends upon, among other things, the aspect and slope of the site.

This past year, we have computed tables showing the relative insolation to be expected over the entire range of slope-aspect combinations on the land for each month of the year. Tables were computed for a latitude of 46° N., but are usable between 43° and 49° north latitude. Some representative values are shown in table 5 to illustrate the strong influence of slope and aspect. It will be

Table 5.--Direct solar radiation received on several combinations of slope and aspect, expressed as the percent of that received on a horizontal plane (46° north latitude)

Month	North aspects		East and west aspects		South aspects	
	20° slope	40° slope	20° slope	40° slope	20° slope	40° slope
March	57	13	102	111	142	195
June	99	98	105	121	104	112
September	68	32	104	116	132	172
December	0	0	100	99	217	375

noticed that in June there is relatively little effect, but in December a 40° slope on a north aspect receives no direct radiation, while the same slope facing south receives almost four times as much radiation as would a horizontal area. Of course, in the overall energy balance, several energy inputs, such as diffuse sky radiation and sensible heat of the air mass, act to reduce the magnitude of differences caused by slope and aspect. Ideally, we should actually measure the different energy inputs under a wide variety of conditions. We plan to do this, but instrumentation problems will delay results. In the meantime, our computed data, shown in table 5, gives us a first estimate.

Soil Temperatures

Studies of soil environment of denuded and normally vegetated sites were started near Wenatchee this fall. We have designed and constructed a precise electric thermometer for measurement of soil temperature. Remote soil temperature readings are being taken to depths of 10 feet. Surface soils when bare are 10° to 12° F. warmer on an average fall day and 14° to 15° F. colder at night than a corresponding site under forest litter and a forest canopy. A cover of perennial grass reduces diurnal variation, but gives less protection than a forest cover.

EROSION AND SEDIMENTATION

Ecology of Eroding Sites

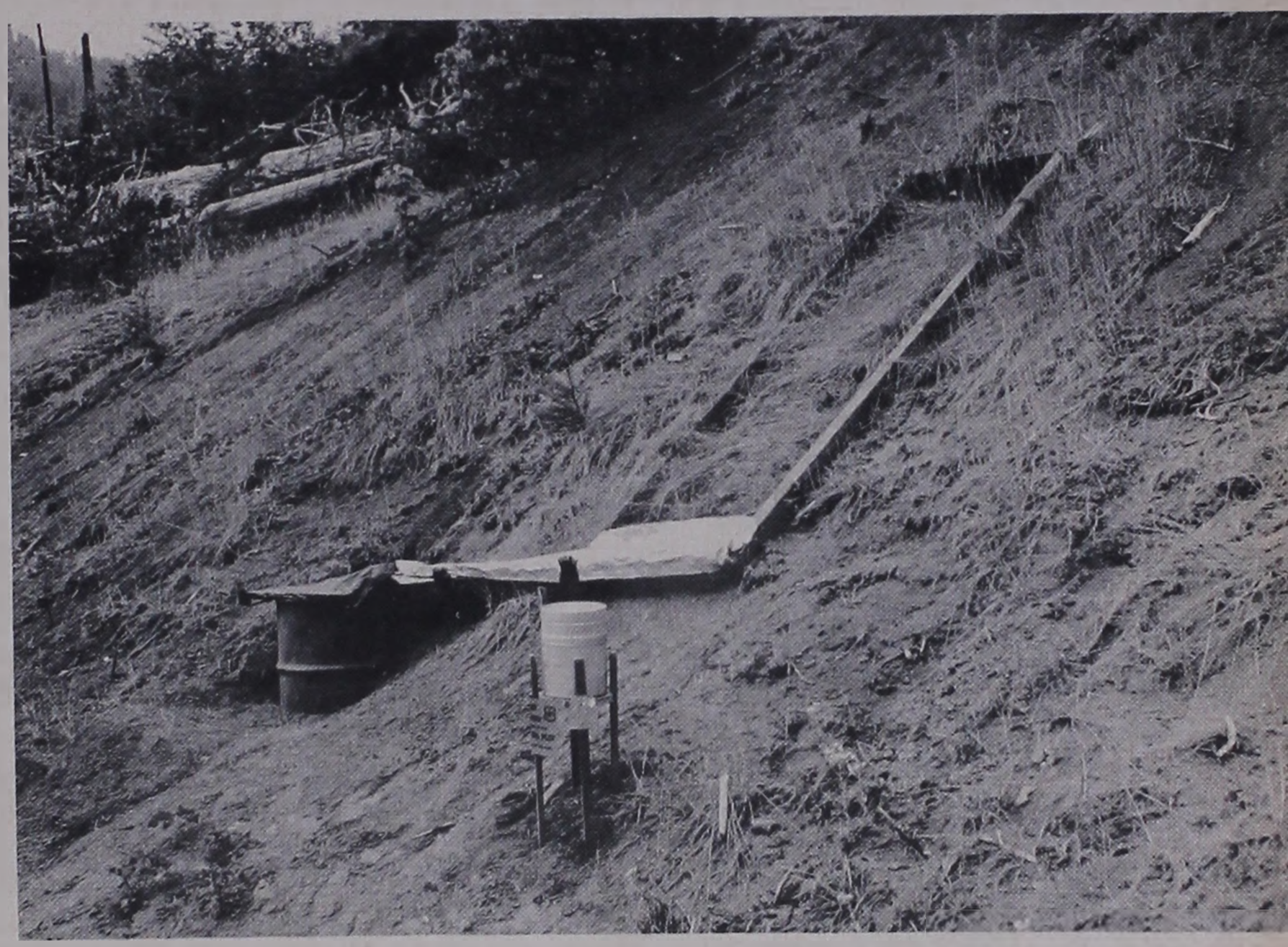
Problems of soil erosion control continue to occupy our attention at Wenatchee. In nearby Mission Creek, measurements on three small drainages have shown that Swauk sandstone soils have eroded at the rate of 1.5 to 2.0 tons per acre per year for the past 4 years. Stimulating the development of an adequate cover of vegetation on bare areas seems to be one of the most promising means of controlling such rapid soil movement. Broadcast application of high-strength chemical fertilizers has resulted in significant increases in vegetative growth.

A typical eroding site on Mission Creek on the Swauk sandstone formation.

Study of normal well-vegetated areas indicates processes and changes in soils which accompany site deterioration in areas such as Mission Creek. Significant differences in stability of various soils are found to be associated with the degree of soil-particle aggregation. Measurements also show that the percent of organic matter accounts for 25 percent of the variations in size of aggregates. Therefore, the upper horizons of the soil mantle, having the highest percentage of organic material, are the most stable. Stability, in turn, decreases with depth, so that removal of the topsoil by erosion will expose subsoil having even greater susceptibility to erosion. Once this condition has been reached, as it has in some parts of Mission Creek, site deterioration proceeds at a faster pace than the process of natural recovery.

Vegetation Stabilizes Roadbanks

The value of vegetative cover in stabilizing soils has been demonstrated by two studies located at H. J. Andrews Experimental Forest. One study of a steep roadbank showed decreased sediment movement when grass revegetated the slope. Soil washed from the plot decreased from 12.7 tons per acre to 2.3 tons per acre annually after a stand of grass covered the soil.



A plot used to study effect of vegetation on a roadbank – H. J. Andrews Experimental Forest.

A second study of broader scope is located in the 250-acre watershed 3, where 1.65 miles of logging road were built during the summer of 1959. About 6.2 percent of the area was affected by construction.

Sediment trends since construction show that carefully designed and properly drained roads will stabilize rapidly. The following tabulation for three

storms compares the maximum suspended sediment in parts per million (p.p.m.) in watershed 3 with that from adjacent undisturbed watershed 2:

Date of storm	Discharge (c.f.s. per sq.mi.)	Suspended sediment-- watershed 2 (p.p.m.)	watershed 3 (p.p.m.)
Sept. 20, 1959	5	22	1,780
November 23, 1960	58	52	1,120
February 10, 1961	72	94	439

Sediment from watershed 2 (undisturbed) increased proportionately as streamflow increased. Sediment from watershed 3 (with roads) decreased with each storm even though streamflow increased greatly. During the first storm after construction, water from the watershed with roads had a maximum suspended sediment content 81 times greater than the undisturbed watershed. Twenty-nine months later, it was only 4.7 times greater. This trend towards stability is expected to continue as the road cut and fill slopes revegetate.

Pint samples taken from streams provide an estimate of suspended sediment.

PLANS FOR 1962

- Intensify study of the effect of logging on streamflow and water quality at H. J. Andrews Experimental Forest. Begin logging on two experimental watersheds, using a conventional high-lead system in one and a 10-ton Wyssen Skyline-Crane in the other.

- Expand current soil studies, giving increased emphasis to the influence of vegetation on moisture and temperature of soil and effects of fertilization on nutrient balance.

- Complete an analysis of erosion problems in the Douglas-fir region, leading to new studies of soil properties important in watershed management.

- Formulate specific plans to integrate field research with fundamental investigations to be made possible by new laboratory facilities.

- Begin studies of microclimate to determine energy involved in evaporation and transpiration.

Forest Disease Research

All diseases, regardless of cause, are strongly affected by physical conditions of the environment.

Abnormally hot, dry weather over most of Oregon and much of Washington, during recent years, has provided striking examples of climatic effects. For the first time in more than 15 years, we note that Elytroderma needle cast has decreased markedly in abundance in eastern Oregon, especially in exposed crowns on south and southwest slopes. This perennial disease of ponderosa pine is believed to spread principally during cool phases of the climatic cycle, and to be intolerant of unusually high summer temperatures.

But conditions that hinder some diseases may hasten damage by others. Our observations indicate that annual mortality from dwarfmistletoe has more than doubled since 1959 in Douglas-fir and ponderosa pine stands. In one ponderosa stand badly infected by western gall rust, losses became so serious during a single summer that immediate logging was necessary. Rapid killing of trees or parts of trees has also been observed associated with attack by other pathogens that ordinarily damage only slowly.

Deteriorating crowns of residuals in a mixed-conifer stand.

In these instances, the part played by weather seems fairly obvious. Far more frequently, relationships between the physical environment and disease are obscure. For example, cooperators report that decline and death of residual Douglas-fir and associated species in southwestern Oregon appear to have become much more rapid during the last 2 or 3 years. The same problem in less acute form has long been recognized in ponderosa pine forests, where crown deterioration of residuals often necessitates repeated cuts at intervals of only a few years. Fungi and insects are probably involved to some extent, but the

usual explanation--too vague to be of much help--is that mature trees cannot adjust themselves to drastically altered environments. Research elsewhere has shown that fine roots of some species are highly sensitive to slight increases in soil temperature, and this suggests that the trouble in southwestern Oregon may have been aggravated by unusual summer heat.

If acute decline of residuals is merely a temporary nuisance caused by abnormal heat, no special measures are needed except increased salvage during occasional warm cycles; if it is going to be a permanent characteristic of partially cut stands, then major changes in management methods are necessary. Definite information on this and similar problems important to forest managers is almost totally lacking. An adequate understanding of diseases will require familiarity not only with pathogens and their behavior but also with the complex physiological relationships that exist between the tree and the inorganic factors of its environment.

SOIL FUNGI ANTAGONISTIC TO PHYTOPHTHORA

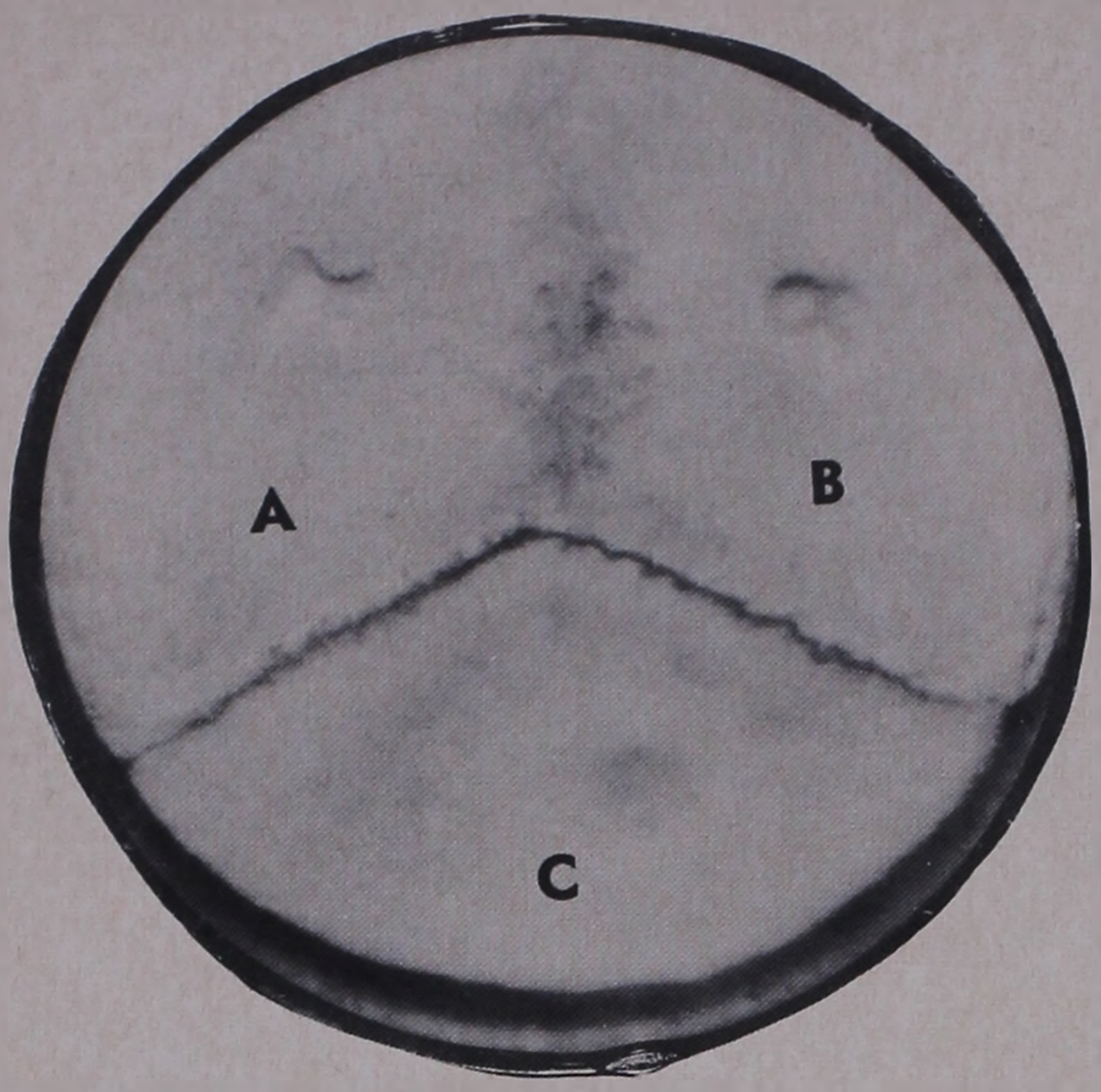
In our research two Streptomyces isolates from forest soil strongly inhibited growth of Phytophthora cinnamomi, a damaging root pathogen, at a distance of several millimeters in laboratory cultures. A few other fungi from the same soil were less strongly inhibitory. These fungi might not keep Phytophthora from infecting roots in this soil, but they are good examples of the natural controls that hold many diseases in check. Natural controls of disease have been given much attention in agricultural research, but are just beginning to be studied in forestry.

TESTS OF ANTIBIOTICS

We have found that two antibiotics, effective against white pine blister rust, failed to control Elytroderma needle cast on ponderosa pine. This does not mean that the disease cannot be controlled antibiotically. Among the large number of antibiotics now known, there may be several that will control Elytroderma. The problem is to find out which ones are of practical value under forest conditions.

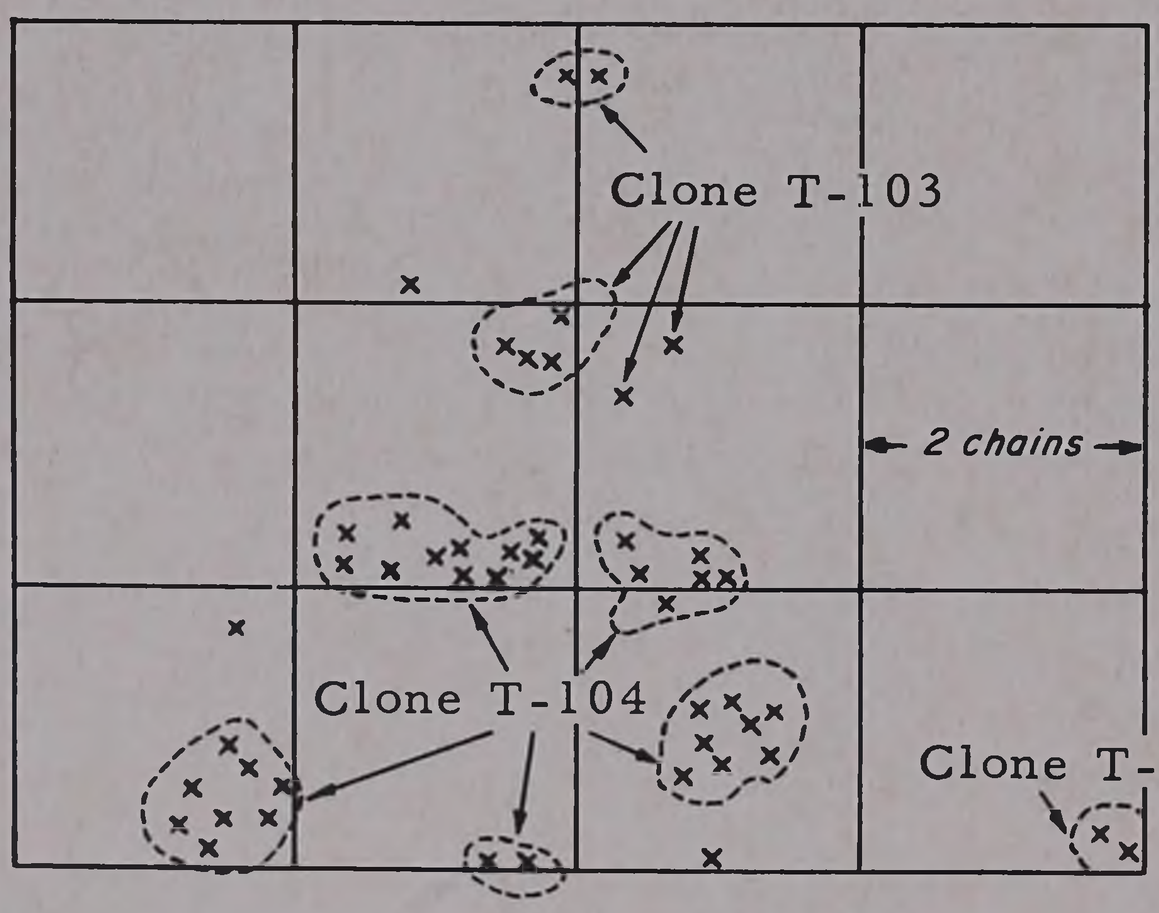
PERSISTENCE AND SPREAD OF LAMINATED ROOT ROT

Centers of laminated root rot (Poria weirii) infection start originally from spores which are genetically different even when produced by the same sporophore. The fungus subsequently spreads by vegetative growth in the vicinity of the original infection, and by spores to greater distances. By cultural methods, we can determine whether infections in different trees have come from the same or different original spore infections--that is, whether they are from the same or different clones of the fungus.



Poria weirii *isolates from different clones. A and B are from trees 20 feet apart, infected by the same clone of the fungus; C is from a tree 400 feet away, infected by another clone.*

Apparently distinct centers of laminated root rot damage, completely separated from each other by zones of healthy Douglas-fir forest, often yield the same clone of the fungus in culture. A highly probable explanation, strongly supported by evidence from other studies, is that the fungus (1) spread vegetatively, sometimes for a distance of several chains, around the point of original infection in a preceding stand, (2) survived in dead roots between the destruction of one stand and the establishment of the next, (3) attacked occasional roots of the new stand as they came in contact here and there with infected material, and (4) created separate centers of damage within the old infection area, by vegetative spread to neighbors of newly infected trees.



Distribution of **Poria weirii** *clones on part of a damage study plot. Dotted lines bound openings caused by the disease; X's represent killed trees.*

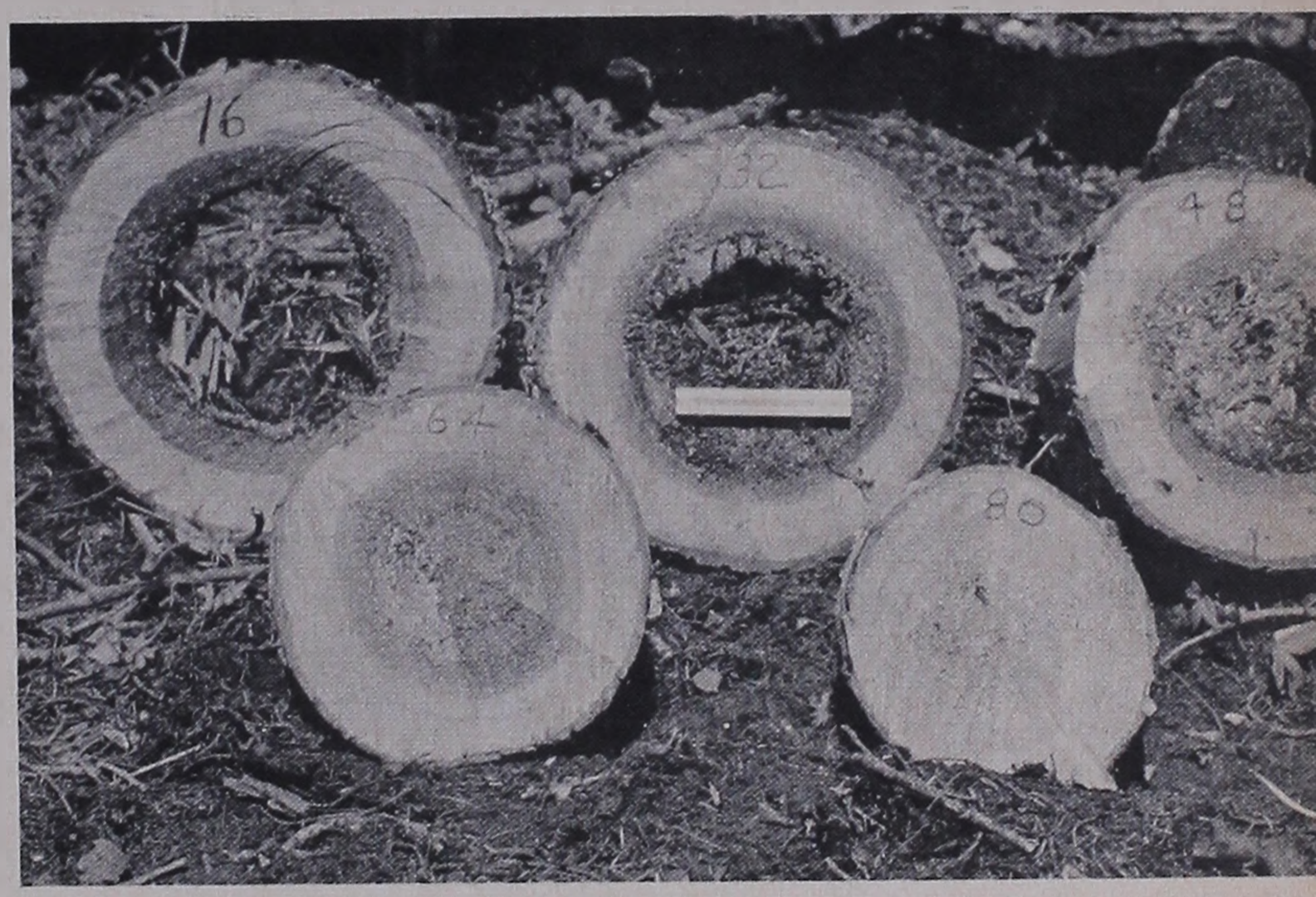
This conclusion raises more questions than it answers. Why is damage not occurring in the intervening healthy zones, where the disease must have been present within the previous or recent rotation? Were the old trees killed so long ago that the fungus died from exhaustion of its food supply before the new stand could be invaded? Or did long continued presence of the fungus gradually increase the effectiveness of natural controls--for example, by building up the population of antagonistic micro-organisms in the soil? How can we change conditions to shorten the survival period of Poria weirii in dead roots, and impede its passage to living ones, so that it will no longer be a serious threat to succeeding stands of Douglas-fir on badly infected areas?

HEART ROTS IN WHITE FIRS AND ASSOCIATED SPECIES

Relative defectiveness of white firs and associated species in the northern Blue Mountains is indicated by these preliminary findings from dissections in two localities:

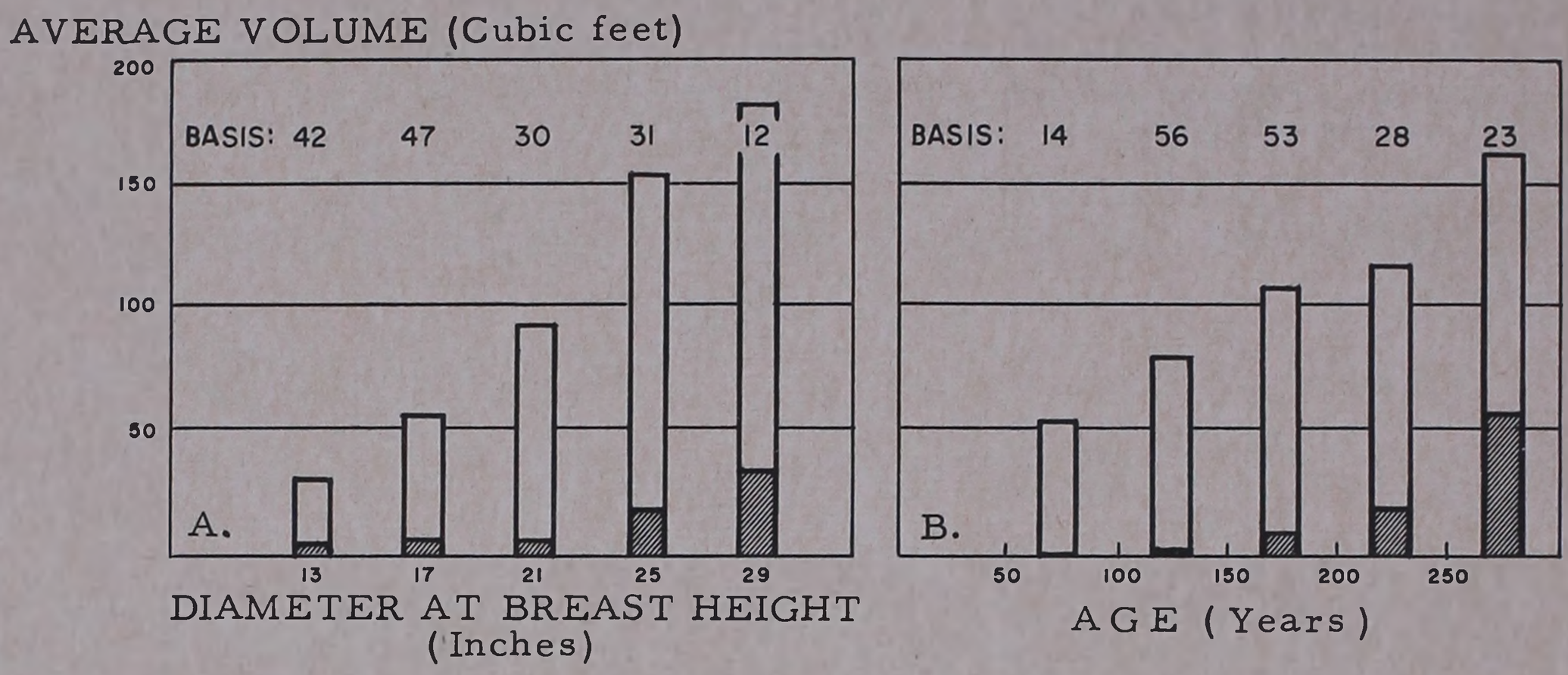
Species and number of trees	Average age (years)	Average d.b.h. (inches)	Volume decayed	
			Cubic feet (percent)	Board feet (percent)
White firs (181)	177	22	15	35
Subalpine fir (18)	148	13	12	28
Douglas-fir (42)	258	22	8	21
Engelmann spruce (103)	154	17	7	14
Western larch (28)	232	26	3	6

Total cull percentages are somewhat higher than decay percentages as shown above, especially for white fir board-foot volumes where additional deductions for frost cracks were common.



Heart rot caused by the Indian paint fungus in white fir. Sections were taken at 16-foot intervals from a tree 193 years old, 22 inches d.b.h., and bearing nine conks.

White fir heart rots are moderately damaging in even the smallest merchantable size classes in wild stands (see accompanying graph A). However, small, decayed trees usually are old, stunted by many decades of suppression. Damage is slight in trees below technical rotation ages (graph B). Heart rots are not likely to be a serious problem in white firs under intensive management, provided that (1) the rotation is not excessively prolonged by low growth rate, and (2) due precautions are taken against root and trunk injuries during cultural operations.



Heart rots in white firs in the northern Blue Mountains. Total bar-lengths represent gross merchantable volumes; hachured portions represent decay volumes. Numerals at tops of bars are numbers of trees in the samples.

PLANS FOR 1962

- Finish the field work on growth analyses of ponderosa pine stands infected by dwarfmistletoe, and start automatic processing of the data.

- Make machine computations of heart-rot data from upper-slope forest types in the northern Blue Mountains, and start field work in another part of the region.

- Continue permanent plot studies of dwarfmistletoe, root rots, needle cast, and other major diseases.

- Staff and equip the Corvallis laboratory and start research there.

Forest Fire Research

Although 1961 was not quite so severe a fire year as 1960, it had more lightning fires than any previous year on record in the Northwest. These two consecutive bad fire years have overshadowed our modest expansion in fire research. However, we have made good progress in planning our future research program, both by learning more about the needs of all fire control agencies in the Northwest and by coordination visits to fire research facilities in neighboring regions. We feel well prepared for the new research we will start in 1962, when we add another scientist to our staff.

1961 FIRE WEATHER IN OREGON AND WASHINGTON

The Station offers fire-weather information service to all fire control agencies in the Northwest.

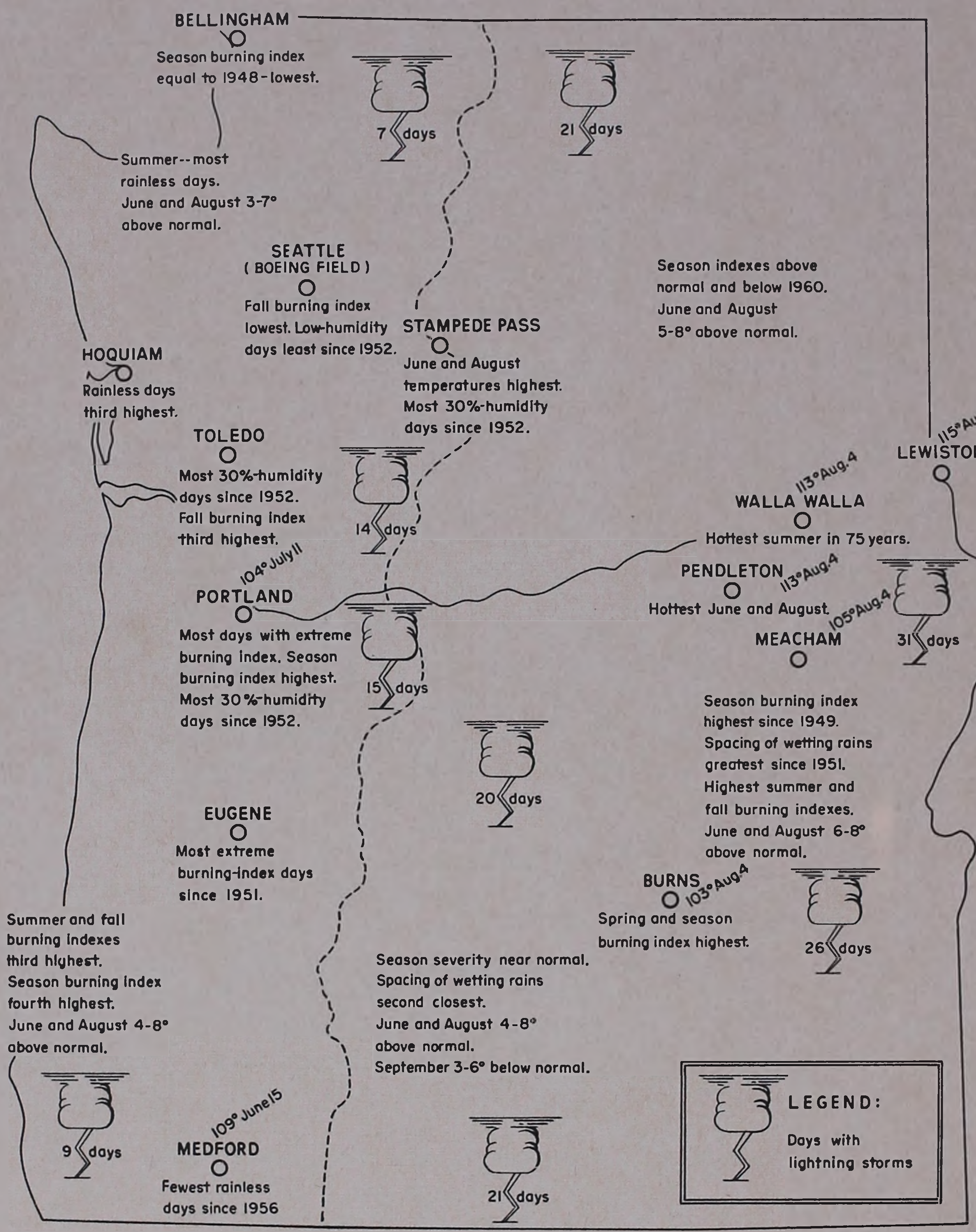
In 1961, summer was unusually hot in the Northwest, and lightning storms started a record number of fires on the national forests. In west-side forests there were more man-caused fires than would have been expected with similar weather before 1957. These highlights are from the Station's 10th annual analysis of fire-weather severity. This was issued as a Station miscellaneous publication and includes more details than previous reports. For the first time, a resume of fire occurrence was included, all three weather indexes were computed for the east side, and fire-weather severity for the entire Northwest was summarized in a single report.

SLASH BURNING

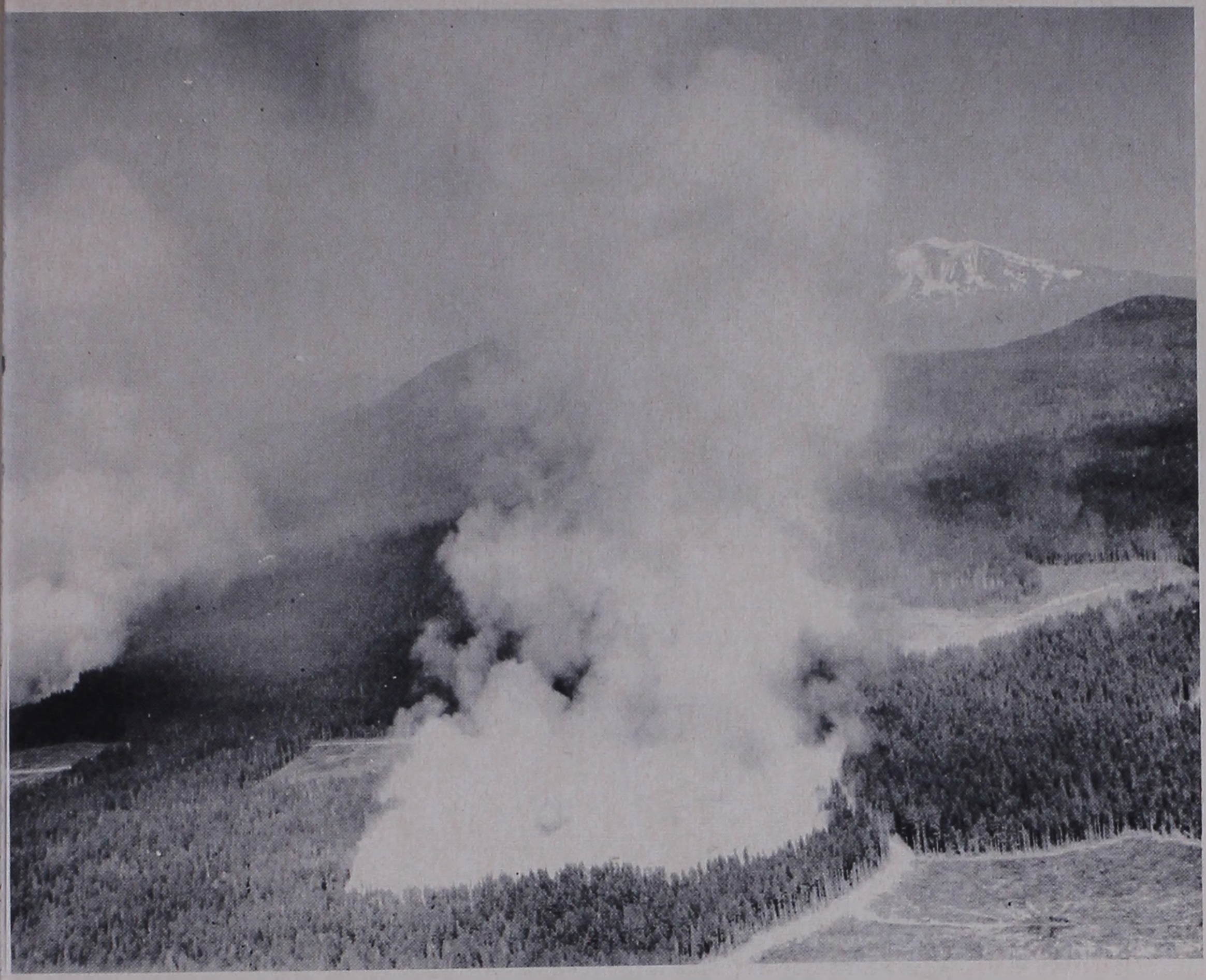
Vast quantities of logging slash on numerous small cutting units are still a major fire hazard. Until means of utilizing this material are developed, prudent land managers will be interested in safe and effective methods of burning these small areas. We have recently tested two electrical instruments to see how useful they would be to those burning slash or to those studying slash burning.

An electric wood-moisture meter was used to measure dryness of slash when burned. When the moisture 1/8 inch below the surface of logs was less than 19 percent, fires on moderate slopes ignited easily with drip torches and spread satisfactorily between sets. We visualized a simple check of a few samples of the different kinds of fuel on a cutting unit to see if conditions were right for burning.

But we found several difficulties. While our samples were from barkless areas on logs, chunks, and limbs, such sampling points are hard to find on some


BELLINGHAM
Season burning index equal to 1948-lowest.
7 days
21 days
Summer--most rainless days. June and August 3-7° above normal.
SEATTLE (BOEING FIELD)
Fall burning index lowest. Low-humidity days least since 1952.
STAMPEDE PASS
June and August temperatures highest. Most 30%-humidity days since 1952.
Season indexes above normal and below 1960. June and August 5-8° above normal.
HOQUIAM
Rainless days third highest.
TOLEDO
Most 30%-humidity days since 1952. Fall burning index third highest.
14 days
115°Aug.4
LEWISTON
113°Aug.4
WALLA WALLA
Hottest summer in 75 years.
104°July11
PORTLAND
Most days with extreme burning index. Season burning index highest. Most 30%-humidity days since 1952.
15 days
PENDLETON
113°Aug.4
Hottest June and August.
105°Aug.4
MEACHAM
31 days
Season burning index highest since 1949. Spacing of wetting rains greatest since 1951. Highest summer and fall burning indexes. June and August 6-8° above normal.
20 days
EUGENE
Most extreme burning-index days since 1951.
BURNS
103°Aug.4
Spring and season burning index highest.
26 days
Summer and fall burning indexes third highest. Season burning index fourth highest. June and August 4-8° above normal.
Season severity near normal. Spacing of wetting rains second closest. June and August 4-8° above normal. September 3-6° below normal.
9 days
109°June15
MEDFORD
Fewest rainless days since 1956
21 days
LEGEND:
Days with lightning storms

1961 fire-weather highlights.



Douglas-fir slash burning on the Gifford Pinchot National Forest. Heavy accumulations of unburned slash on small clearcuts increase danger to surrounding green timber.

slash areas, even where there is lots of slash. Bark, rotten spots, or heavily weathered areas are to be avoided. Furthermore, the exposure of each sample should be uniform, so the "slope" and "aspect" on each sample log should be similar. One last difficulty is that the meter reading must be corrected if the wood temperature differs from 70°. These corrections may be as great as one-fifth of the indicated moisture.

Since we didn't find a convenient means of direct moisture measurement, we reexamined the use of half-inch indicator sticks as guides to burning conditions. Several hundred records of slash burns confirmed previous findings: west-side slash will burn readily in clearing weather following a fall rain when sticks in the open are below 14 percent moisture content. Stick moisture criteria should be a little higher for steep southerly slopes and lower for flats and northerly

slopes. If moisture content of sticks under adjoining timber is above 20 percent, spot fires there will give little trouble.

The other instrument tested measured temperatures of distant flames. In addition to determining the range of temperatures on slash fires, we hoped to find an objective method of measuring fire intensity. Such measurements could be related to weather, slope, and type of fuel in developing better guidelines for slash burning.

We found that measured temperatures of both large and small flames were generally between 1,650° and 1,700° F. Glowing charred logs with no flames and with interspersed spots of glowing charcoal were about 1,250°. But, there were inherent limitations of the instrument that prevented an acceptable rating of slash-fire intensity.

FIRE DANGER RATING

We were asked to recommend a means of rating current severity of the fire season on the national forests of Region 6. Our system of rating 6- to 13-week segments of the season could not be readily converted to this use. After investigating several ways of keeping track of the cumulative drying of deep fuel beds or heavy fuels, we suggested the trial use of the California buildup index since it was easiest to compute and indicated fluctuations in dryness similar to the other methods. This was used this past summer as a factor to modify manning and specific action guides. Previously, these were based on burning index, lightning probability, other risk, and visibility. Now, preparedness is increased when the buildup index is high.

BETTER USE OF WEATHER INFORMATION

There are many opportunities in the Northwest to improve fire control by better use of fire-weather information. We listed several examples of this in a report prepared in cooperation with the Division of Fire Control, U.S. Forest Service. To follow up on some of the recommendations in this report, a cooperative pilot plant test of increased use of fire-weather information will be made next summer.

Part of this test may affect the fire-weather service offered to all fire control agencies in the Northwest. A preliminary statement has been prepared as a starting point from which fire control organizations may define their needs for fire-weather information. The final statement will not only serve as a guide in planning the increased service called for by the National Plan for Fire-Weather Service, but will also define the supporting services to be provided by the fire control agencies. These include communications, weather observation, and weather-station maintenance. Many of these increased services will be tried in the Northwest next summer.

CASCADES FIRE-WEATHER PROJECT

Fires in the forests of the Northwest are greatly influenced by weather variations that, because of the effects of the mountainous terrain, are complex and little understood. These weather idiosyncracies usually become apparent at most inopportune times--when they affect fires. Normally, they are not reported or even observed by the sparse network of fire-danger stations.

To acquaint forecasters and fire control personnel with these weather variations, we must first learn what variations occur and their causes. The Cascades Fire-Weather Project has been proposed to develop this information. This will be a cooperative field project in which Federal and State fire control agencies and the Weather Bureau will have an interest.

We have begun preliminary studies to explore procedures for analyzing weather patterns in the Cascade Range, using all available data for a few weather situations. A special fire-weather analysis map on a topographic base has been prepared and several cross-section profile charts are being constructed. This and other preliminary studies will help to define the form the field project will eventually take.

In another preliminary step, we prepared the initial draft of a priority list of "Fire-Weather Research Needed in Oregon and Washington" covering 42 study areas. After revision by other committee members, the list was issued as a report of the Fire-Weather Committee of the Oregon and Washington Forest Fire Research Councils. The Cascades Fire-Weather Project will investigate eight of the highest priority problems. In general, these include observation, analysis, and understanding of weather variation in mountainous terrain.

PLANS FOR 1962

- Continue planning and trials of techniques for cooperative Cascades Fire-Weather Project.
- Cooperate with Region 6 of the U.S. Forest Service in pilot plant test of intensified fire-weather services.
- Report on 1962 fire season.
- Cooperate with Region 6 of the U.S. Forest Service to complete statement of fire control agencies' need for fire-weather services.
- Test use of the proposed National Fire Danger Rating System in the Northwest.
- Determine effect of slash burning 9 to 16 years ago on the fuel hazard, restocking, and cover in the Douglas-fir region.

- Observe slash-burning fires in the Douglas-fir region to improve the field sampling of fuel moisture and devise or find an instrument to rate slash-fire intensity.

- Continue research on factors that must be considered and methods of combining them to give a more reliable classification of fuel hazard.

- Study free-burning fires and improve the field measurements, descriptions, and records of factors influencing behavior.

- Investigate the relation of diurnal relative humidity curve and moisture content of several kinds of Northwest forest fuels.

Forest Economics Research

The economic aspects of wildland resource management and use have grown in importance even faster than the growth of the Nation's needs for wood, water, wildlife, forage, and recreation. We have been expanding our program to contribute more toward the solution of economic problems--problems whose solutions lie in an understanding and analysis of costs in relation to expected benefits, tangible and intangible, direct and indirect, individual, local, or national.

There are now 18 professional staff members in forest economics research. Eight of these have advanced degrees in economics of which six are doctorates. Of the other staff members, five have advanced degrees in forestry. Other staff members are in various stages of graduate study.

Our studies of timber trends in the Douglas-fir subregion and of the eastern Oregon industry and resource are being prepared for publication. These studies will contribute to a strengthening of the forest products industries and, consequently, to sounder, more intensive management of forest lands.

As we near completion of a study of the costs and results of relogging in western hemlock, we are also planning the continuation and expansion of our studies of logging costs. New work will evaluate a radio-controlled skyline crane at Cascade Head Experimental Forest, a similar skyline system using different equipment at the H. J. Andrews Experimental Forest, and thinning operations in Columbia County.

Some of the more interesting progress of the past year is reported here.

FOREST SURVEY

During 1961, approximately 5.5 million acres of commercial forest land were reinventoried in Oregon. One-third of this was on three national-forest working circles where the work was carried on by national-forest inventory crews. The remaining 3.7 million acres were inventoried by Forest Survey crews in the Oregon counties of Benton, Clackamas, Clatsop, Columbia, Hood River, Linn, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill. The previous inventories for most of these counties were made during the early 1940's.

Reports of the forest inventories in Okanogan, Clallam, Jefferson, King, Pierce, and Kitsap and Island Counties, Washington, have been prepared and will be published early in 1962. Preliminary estimates of forest land area and volume are shown below.

County	Commercial forest area (thousand acres)	Growing stock volume (million cubic feet)
Okanogan	1,686	3,096
Clallam	728	3,371
Jefferson	542	3,709
King	825	3,850
Pierce	617	2,281
Kitsap	206	413
Island	87	200

Compilation of inventory data for Chelan, Douglas, Ferry, Spokane, Stevens, Pend Oreille, Lincoln, and Whitman Counties, all in Washington, is almost complete and reports will be published in 1962.

Objectives and standards revised in 1960 broadened the scope of the Forest Survey in order to develop better data for evaluating forests and forest land in terms of factors affecting productivity. At the same time, slightly revised and more definitive standards for determining stocking type and size class were established. All of these revisions made it necessary to write new field procedures which were put into use in 1961.

WESTERN WOOD DENSITY SURVEY

As a result of the contribution of western forest industry to this project (page 79), added impetus was given to phase I--the collection of increment cores from standing trees on field plots dispersed systematically throughout Oregon and Washington. During 1961, an additional 4,200 increment cores were collected, bringing the total to date for Oregon and Washington to slightly over 6,000 cores. Although cores are being collected from all commercial species encountered, the primary species with which the wood density study is immediately concerned are:

Douglas-fir	Pacific silver fir	western larch
white fir	California red fir	noble fir
western hemlock	grand fir	cottonwood

Phase I is now 35 percent complete in Oregon and 90 percent complete in Washington, or 56 percent complete for the two States.

RESOURCE AND INDUSTRY ANALYSIS

In cooperation with the Bonneville Power Administration, we have started a 2-year project to forecast, by 5-year periods from 1965 to 1980, production and employment in logging and in lumber, plywood, fiber, and chemical segments of the wood industries in the States of Idaho, Oregon, Washington, and the 11 counties in Montana west of the Continental Divide. This will be used as a basis for evaluating future electrical power requirements.

THE ECONOMY OF ADVANCE ROADING IN SECOND-GROWTH TIMBER

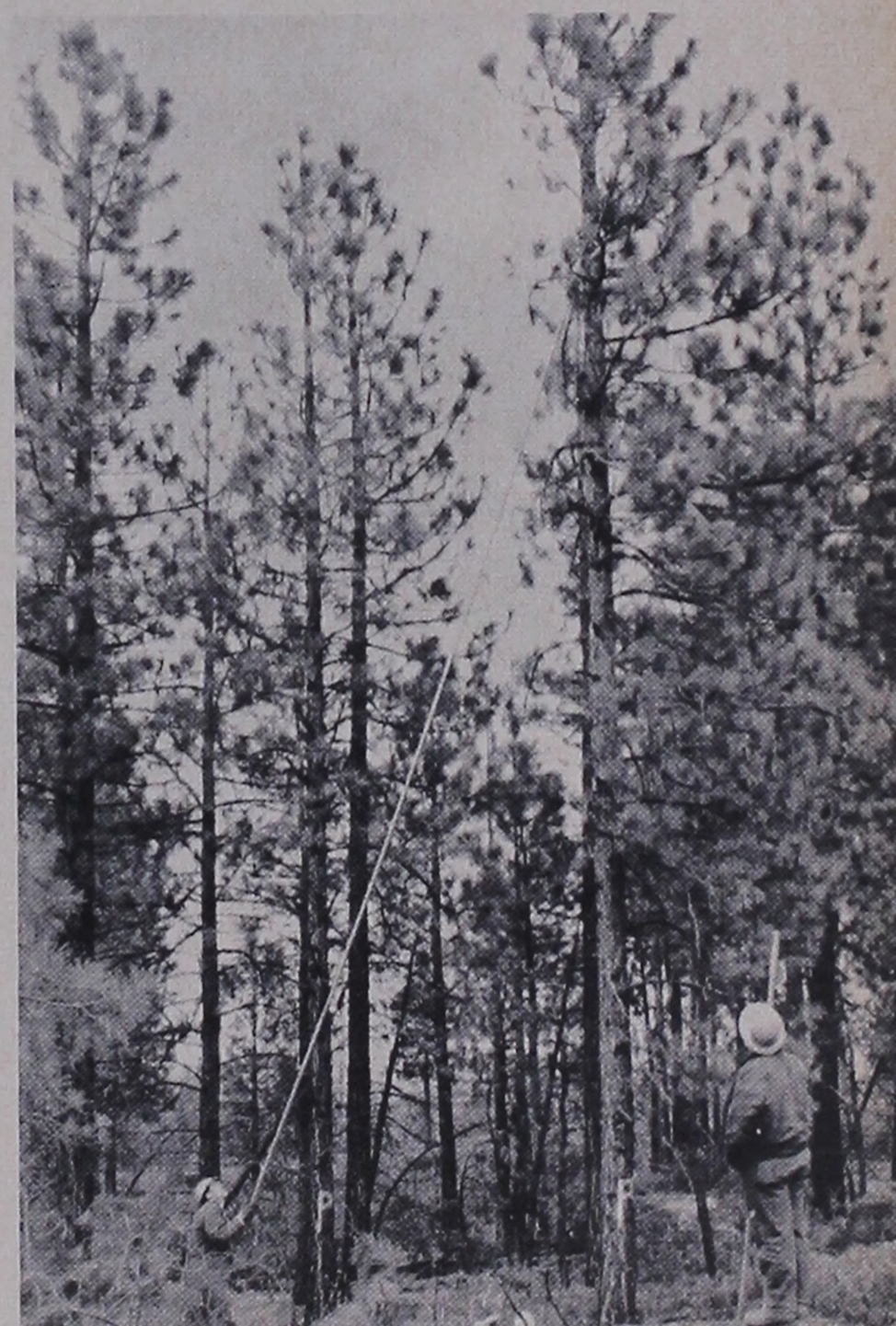
A common problem in thinning young stands of Douglas-fir on large ownerhips is the justification of road investments of $50,000 to $60,000 per section, 0 to 40 years in advance of the time they would otherwise be needed for final arvest cuts. The objective of this study is to quantify the extra yields and econmies available through advance roading and scheduled thinning, and to express hem as a rate of return on the undepreciated portion of the road investment.

The study is being conducted on a 3,650-acre area of the Clemons Tree Farm with the cooperation of the Weyerhaeuser Co. and the University of Washington. The predominant type is Douglas-fir and associated species in age classes 30 to 70 years. Trial markings for first thinnings on site I areas reveal a volume of 5,000 to 10,000 board feet per acre, Scribner rule, ready for initial harvest.

COST OF PONDEROSA PINE DWARFMISTLETOE CONTROL

Initial field work has been completed on a study of the cost of eradicating dwarfmistletoe from ponderosa pine stands. Infected trees or branches have been removed in a silvicultural thinning and pruning operation on a central Oregon study area. It is anticipated that the area must be treated again in 3 to 5 years to remove latent and unobserved infections.

Over 80 combinations of stand density, tree size, and infection intensity have received treatment in order that forest managers may learn the extra



Three-fourths of a 40-foot sectional pole saw is used to remove an infected limb in the pruning phase of the dwarfmistletoe control study.

investment required for mistletoe control over and above silvicultural stand-improvement costs, throughout a broad range of stand conditions. Ultimately, growth-impact information will permit determination of the economic consequences of dwarfmistletoe control in terms of rates of return on investment. This, in turn, will be the basis for establishing guides to be used by forest managers in deciding upon the use of control measures.

ALTERNATIVE MANAGEMENT PLANS FOR AESTHETIC-TIMBER ZONES

The objective of this study is to evaluate alternative management plans for aesthetic-timber zones in the west-side Douglas-fir type. The study plan and the major part of the field work are completed.

The final report is being designed as a working tool for forest management planning where the management objective requires a combination of aesthetic appearance and timber production. For each management alternative, the value of wood production will be expressed in terms of net present worth. A series of photographs will illustrate the stand's expected appearance.

Forest Service recreation survey data indicate that over 5 percent of the commercial forest land on national forests in the Douglas-fir subregion should be managed for a combination of appearance and timber production.

Old-growth Douglas-fir on the Rogue River National Forest -- uncut.

Old-growth Douglas-fir on the Rogue River National Forest after salvage and partial harvest operation designed to encourage Douglas-fir reproduction, but without marring aesthetics.

Sixty-five-year-old Douglas-fir on the E. P. Stamm Industrial Tree Farm -- unthinned.

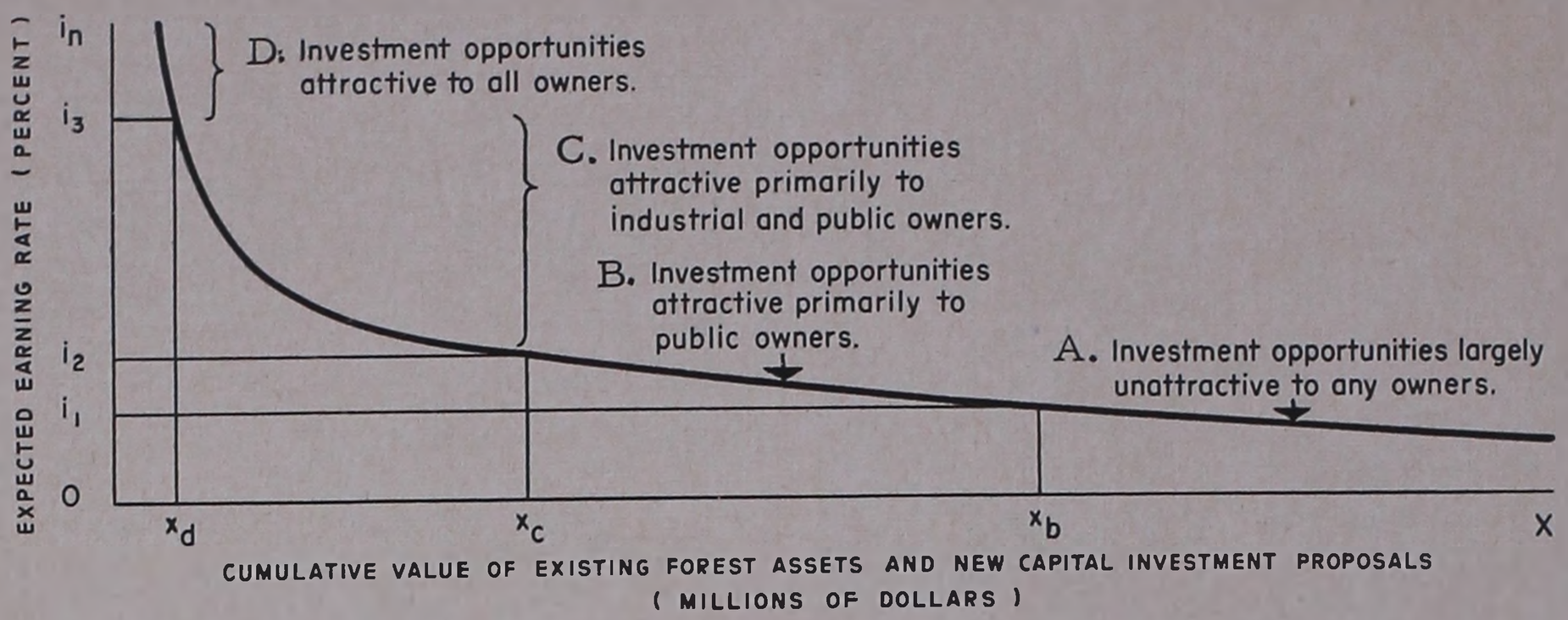
Sixty-five-year-old Douglas-fir on the E. P. Stamm Industrial Tree Farm -- thinned several times since 1950.

We plan to publish a preliminary report of practices that have been employed and photo illustrations of the resulting appearances.

OUR ANALYSIS OF FOREST MANAGEMENT INTENSITY

Because forestry inherently requires heavy capital investment together with owner ability to maintain and increase such investments, the earning rate in forestry is a critical determinant of management intensity. Comparison of earning rates in forestry with rates in other investment alternatives indicates why nonindustrial owners so frequently reject intensive management. They cannot afford it. Viewed in this light, the goal of greatly increased timber production must be distinguished from the problem of how best to achieve this production. The solution to the problem is to stimulate higher levels of forestry investment among all classes of owners.

An idealized model suggests how public effort can best be allocated to achieve increased production. Essentially the model calls for identifying those capital investment proposals that can and should be undertaken voluntarily by public, industrial, or nonindustrial owners. Using this approach, types of additional public and private investment are revealed that will actually further expand timber production and not result in a substitution of public for private investment. The objective of the model is to provide a guide for obtaining an optimum allocation of production from forest lands in the country by a program that avoids conflicts with economic self-interest of individual private owners.


EXPECTED EARNING RATE (PERCENT)
i_n
i_3
i_2
i_1
0
D. Investment opportunities attractive to all owners.
C. Investment opportunities attractive primarily to industrial and public owners.
B. Investment opportunities attractive primarily to public owners.
A. Investment opportunities largely unattractive to any owners.
x_d
x_c
x_b
X
CUMULATIVE VALUE OF EXISTING FOREST ASSETS AND NEW CAPITAL INVESTMENT PROPOSALS
(MILLIONS OF DOLLARS)

Idealized model of aggregate capital demand schedule for commercial forest holdings of public, industrial, and nonindustrial owners.

EXPORT OF LOGS TO JAPAN

As a consequence of a rapid increase of log exports to Japan which drew criticism from some segments of the lumber industry, we were asked to report on the rate of log and lumber exports and to examine the effects on the regional economy. We estimated that in 1961, log exports from the Douglas-fir subregion would amount to about 250 million board feet, Scribner scale, exclusive of Port-Orford-cedar. Although this is only about 2.5 percent of the subregion's annual log production, impact has been heaviest in port areas and has exerted an upward pressure on log prices. However, benefits have accrued to the extent that much of the employment and income from log exports represented extra logging and extra income that would not otherwise have occurred, and has encouraged thinning of young stands. Recent discussions have related log exports to other problems of the region's lumber industry: overcapacity relative to the market for Northwest lumber; increased competition from other producing areas; and loss of some lumber markets to plywood, fiberboard, plastics, and light metals. U.S. log and lumber exports to Japan for selected years were as follows:

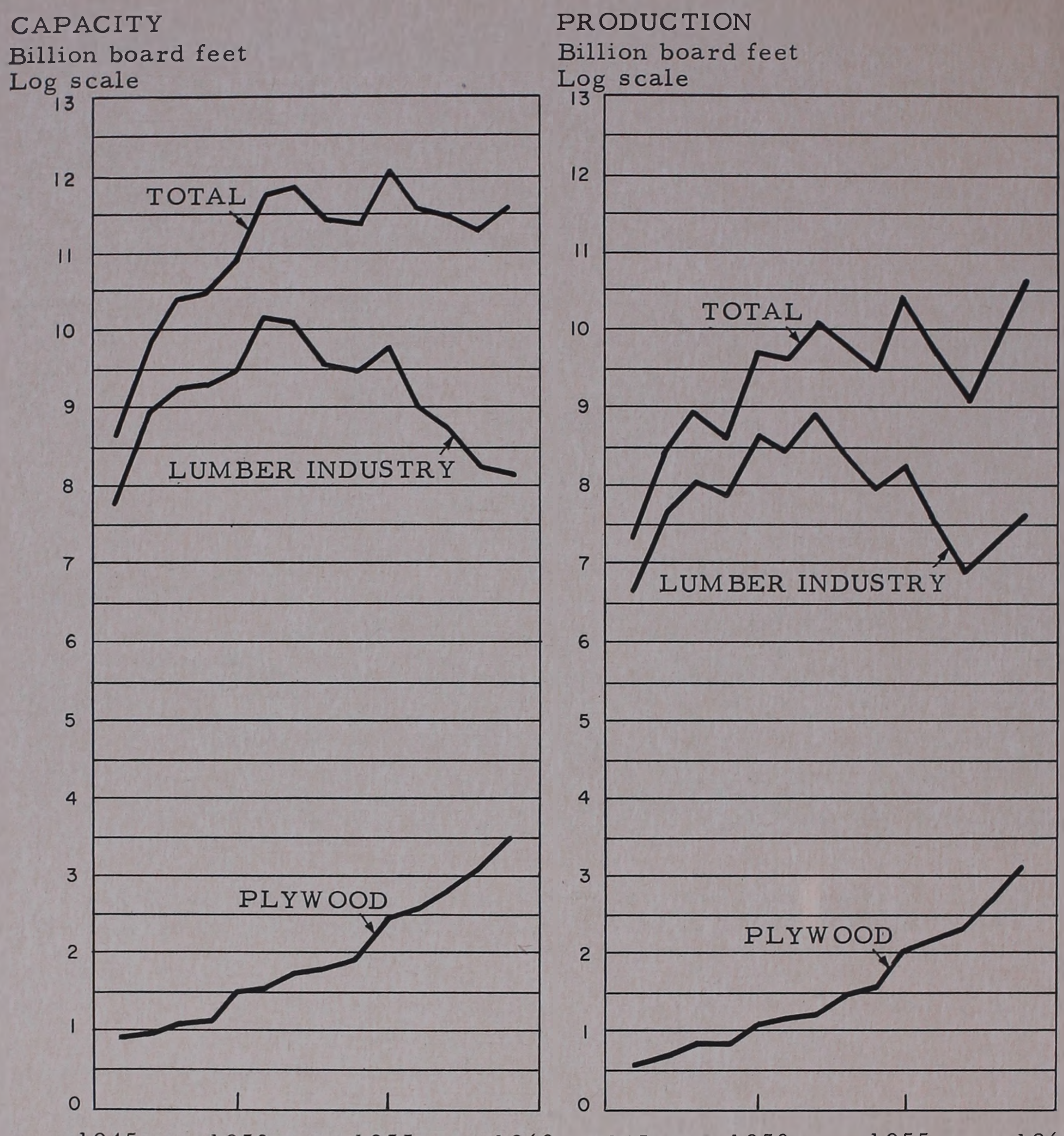
Year	Logs, Scribner rule	Lumber
	(M board feet)	
1930	221,260	330,325
1935	191,154	188,918
1940	22,890	47,138
1945	--	--
1950	--	5,828
1955	18,066	29,648
1960	98,553	55,746
1961 Oregon and Washington only (first 9 months)	173,203	108,102

Douglas-fir thinnings, not much larger in diameter than car stakes, being loaded for export overseas. Development of this market has aided forest management of young stands. Larger saw logs were also exported.

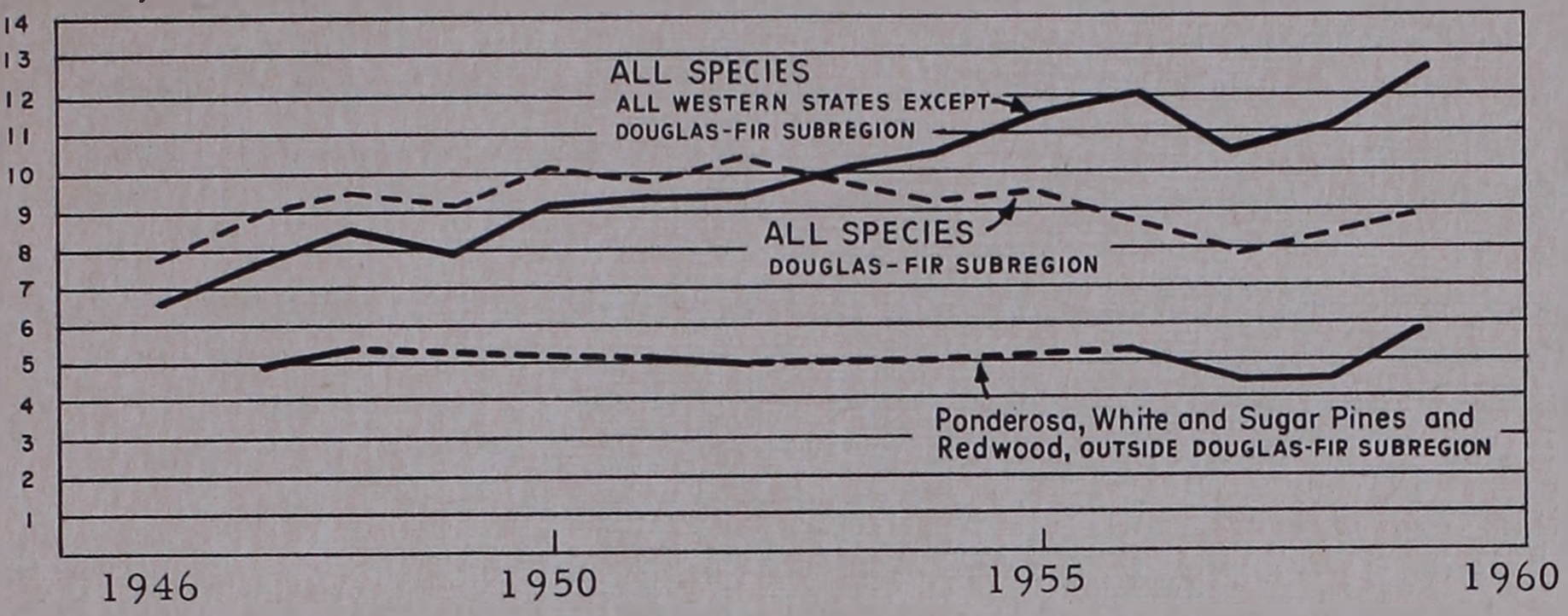
RELATIONSHIPS BETWEEN PLYWOOD AND LUMBER INDUSTRIES OF THE DOUGLAS-FIR SUBREGION

The capacity of the Douglas-fir lumber industry reached a peak in 1951 of 11,943 million board feet in terms of lumber output or 10,208 million board feet, log scale. Plywood capacity in that year was 3,579 million square feet or 1,556 million board feet, log scale. The combined capacity in terms of log input was 11,764 million board feet, log scale. Since 1951, the combined plywood and lumber industry capacity has remained at the same level while lumber capacity has declined in every part of the Douglas-fir subregion. Plywood increased its share of the combined capacity at an average rate of 2 percent per year--from 13 percent in 1951 to 30 percent in 1959.

The 500-million-foot log requirement of the plywood industry in 1940 was only about 6 percent of the total log production of the Douglas-fir subregion, or



Capacity and production of the lumber and plywood industries of the Douglas-fir subregion, 1946-59. (Capacity is based on 117 board feet of lumber and 230 square feet of 3/8-inch plywood per 100 board feet of log scale.)



Lumber production in the western States, 1946-59.

11 percent of the log production in western Washington where the industry was concentrated. Log requirements of the plywood industry now are approximately 3 billion board feet. This is about 30 percent of the total log production of the subregion compared to the 6 percent in 1940 and to 10 percent in 1950.

During this same period, there has been a strong movement toward integration of these two industries. In 1950, 31 percent of the plywood capacity was integrated with lumber production under the same ownership, about the same as in 1937. By 1955, 40 percent of the plywood capacity was integrated with lumber and in 1960, 43 percent. In Oregon, which now accounts for two-thirds of the total log production in the Douglas-fir subregion, 47 percent of the plywood capacity has been integrated with lumber since 1955. In 1950, only 26 percent was so integrated. The full force of the integration movement, however, is not revealed until account is taken of the expansion of plywood capacity from 3,476 million square feet in 1950 to 9,172 million square feet in 1960. The amount of plywood capacity integrated with lumber production quadrupled between 1950 and 1960.

The capacity of the industry in the Douglas-fir subregion declined about 2.5 billion feet from the peak level of 1951 to 9,494 million board feet of lumber in 1959. This decline, however, has been more than offset by expansion of the lumber industry in California and other western States. Thus, while the lumber industry for the Douglas-fir subregion has declined significantly since 1951, the lumber industry for the 11 western States has expanded, more than offsetting the decline. Since production of ponderosa, sugar and white pines, and redwood has remained about the same since 1951, the expansion apparently has been largely in Douglas-fir and it in construction uses.

Our study of industrial capacity in the Douglas-fir subregion is now near completion. Final results will relate forest industry capacity to production, employment, and log supply.

STRUCTURE OF DOUGLAS-FIR LUMBER INDUSTRY

Our economic research has produced data on the degree and trend of competition in the lumber industry compared to competing industries. Merger activity in the lumber industry has proceeded at an accelerated pace during the decade of the 1950's, surpassing that of any other manufacturing industry in the United States. Of the 20 largest firms producing lumber in the Douglas-fir subregion in 1947, 8 disappeared through the merger process, 3 ceased operations entirely, and 1 became a cooperative. The accompanying table shows the share of lumber production accounted for by the 4 largest, the 8 largest, and the 20 largest producers in the Douglas-fir subregion and in the United States, at three different points in time.

Table 6.--Economic concentration in lumber production during 1947, 1954, and 1959

Area and year	Total lumber production	4 largest producers		8 largest producers		20 largest producers	
		Lumber production	Percent of total	Lumber production	Percent of total	Lumber production	Percent of total
	Million bd. ft.	Million bd. ft.		Million bd. ft.		Million bd. ft.	
Douglas-fir subregion:							
1947	8,962	1,429	15.9	1,847	20.6	2,691	30.0
1954	9,283	1,538	16.6	2,030	21.9	2,905	31.3
1959	8,892	1,961	22.0	2,511	28.2	3,471	39.0
United States:							
1947	35,404	1,687	4.8	2,274	6.4	3,471	9.8
1954	36,356	1,846	5.1	2,528	7.0	3,849	10.6
1959	37,055	2,941	7.9	4,114	11.1	6,135	16.6

For both the Douglas-fir subregion and the Nation, concentration of output among the largest producers remained approximately unchanged from 1947 to 1954. However, the merger movement produced a significant increase in concentration over the shorter period of 1954 to 1959.

The degree of competition in the lumber industry may be compared with other industries in the building construction field. Measured in terms of value of product shipments in 1954, the four largest producers of sawmill and planing mill products in 1954 accounted for only 6 percent of total value of product shipments, as shown in the following tabulation:

Standard industrial classification	Product classification	Total accounted for by four largest firms (percent)
32711	Concrete block and brick	3
2421	Sawmill and planing mill products	6
3442	Metal doors, sash, and trim	12
3251	Brick and hollow tile	13
2432	Plywood	16
3241	Cement, hydraulic	31
2823	Plastic materials	45
26132	Insulating board and hardboard	61
3272	Gypsum products	89
33126	Structural steel shapes and piling	92
33521	Aluminum plate and sheet	93
32112	Plate glass	98

This is an exceedingly low concentration ratio (high degree of competition). At the other extreme is the plate glass industry where the four largest producers accounted for 98 percent of all plate glass shipments.

Simultaneously with mergers of the largest mills, small lumber mills were dropping out of the industry at a rapid rate. From 1948 to 1959 the number of sawmills in production declined from 1,675 to 630. This is a decline of 62 percent in number of producing units. Almost the entire disappearance is accounted for by mills that produced less than 40,000 feet per day. In the same interval, the larger mills expanded in output so that total lumber production declined only 5 percent.

Increased concentration in timberland ownership within the Douglas-fir subregion also reflected the merger movement of the 1950's. In 1953, the four largest firms in the region owned 22.4 percent of all privately owned timberland. The share of the four largest increased to 26.2 percent by 1960. This degree of concentration among the big four was relatively high when it is considered that logs, unlike most other products, can be transported over only very short distances.

The above data indicate that the lumber industry at the production level is one of the most competitive industries in the entire U.S. economy. Concentration of production and timber ownership has increased substantially under the impact of an accelerated merger movement.

PLANS FOR 1962

- Special effort will be made to complete as much reinventory work as possible in southwestern Oregon counties, especially those which have not been inventoried within the last 10 years.

- With the assistance of Bonneville Power Administration, we will begin to assemble the latest forest resource and industry facts as the basis for estimates of resource and industry conditions in the near future.

- With the assistance of the forest industry and other public agencies, we will complete phase I, the collection of increment cores, for the Western Wood Density Survey.

- Our program in the economic evaluation of timber growing opportunities and of multiple-use management will continue to be emphasized.

- We will concentrate on logging cost analyses and on problems of public timber sale and appraisal.

Survey Techniques Research

Survey techniques studies are conducted to develop improved methods of making forest land inventories, timber management plan surveys, and forest insect surveys. This work is conducted jointly with Region 6, U.S. Forest Service, the latter carrying out administrative studies directed toward problems of application. In the past, formal studies in this field have been restricted to aerial survey methods. However, last year the inventory phase of the program was broadened to include other survey and mensuration techniques.

This year's effort was concentrated on two objectives: the completion and reporting of existing studies; and a reorientation of the research program based on an analysis of the needs.

FOREST INVENTORY AND MANAGEMENT SURVEYS

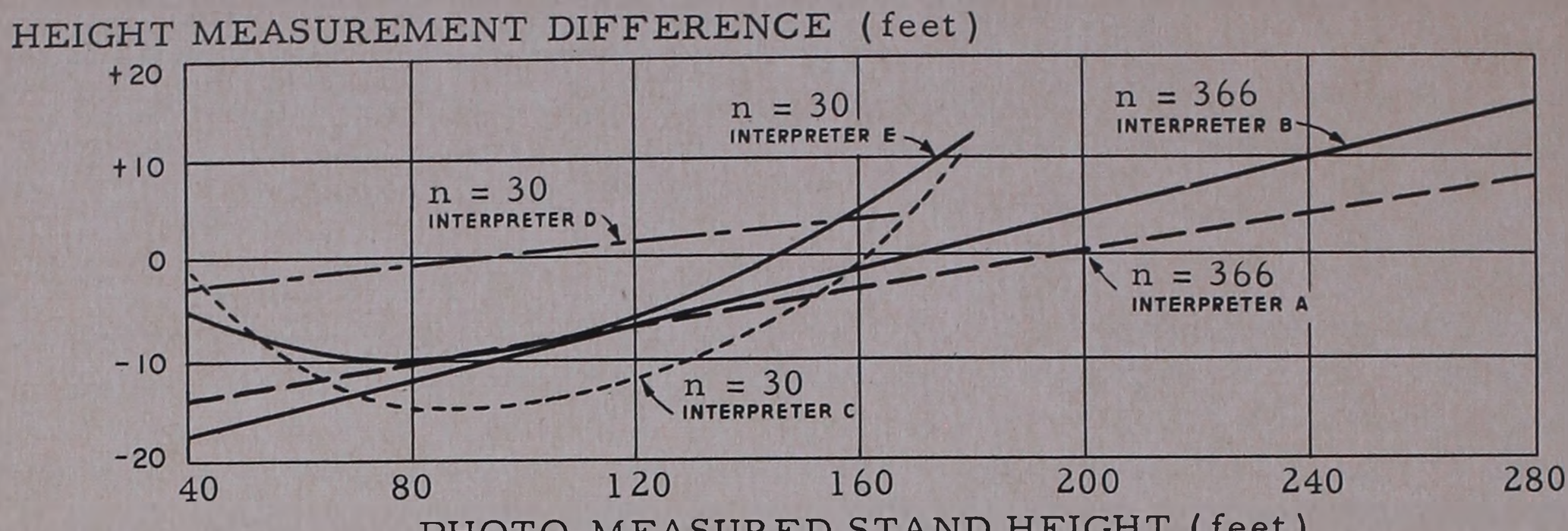
Program Reorientation

Our new program of Forest Survey techniques research is based on an analysis which weighed the relative value of various Forest Survey data items, the need for improved methods of collection or analysis, and the likelihood of success in developing better techniques. The resulting program places highest priority on a group of studies aimed at insuring that our current survey procedures will provide the trend information we need.

We also took a new look at the need for improved methods of obtaining forest management data from aerial photos. As a result of this, we broadened our program to include timber sale preparation and timber stand improvement work as well as management inventories.

Aerial Photo Volume Tables

While developing aerial photo volume tables for Douglas-fir, we investigated a number of the problems that complicate photo volume table construction. One such problem is the bias that occurs when stand heights are measured on aerial photographs. We found that this bias changes with stand height, that its pattern varies considerably from interpreter to interpreter, but that all interpreters underestimated short stands and overestimated tall stands. We are preparing a publication which describes the procedures used to construct the Douglas-fir photo volume tables, the problems encountered, and the methods used to solve them.



Differences in photo measurement of stand heights by several interpreters.

Supplementary Photo Plots

We collected some additional data on the accuracy of estimating stand size and stocking class from aerial photos. It confirmed our previous tentative conclusion--that this supplementary information is useful only in limited areas where the stands are predominantly even aged and well stocked.

We are now testing several methods for using aerial photographs to stratify by volume classes. These range from the simple ocular estimation of stand-size class to the more complex procedure of using photo volume tables. All methods produced substantial improvements in the sampling error for total volume estimates. In general, the more complex and expensive the method, the better the stratification, suggesting that no method is substantially more efficient than the others. However, the results have varied somewhat, depending on interpreter and area, and more tests are needed before firm conclusions can be drawn.

Lithographed Forest Stereograms

We evaluated a series of forest stereograms made by a fine-screen lithograph process to see if they could be substituted for the more expensive photographic reproductions as training and reference aids. They proved very satisfactory for teaching angle and distance measurement, and for the identification of broad features. However, they were judged not suitable for detailed interpretation, such as forest type identification or the measurement of forest stands.

Guides for Two-Story Type Mapping

We have prepared a series of matched aerial and ground stereograms illustrating typical two-story stands in the Douglas-fir subregion. They will serve as training aids and reference guides for those making type maps. And they

should aid in the forest manager's understanding and interpretation of two-story type maps.

FOREST INSECT SURVEYS

Program Reorientation

An analysis of the research needs in the field of forest insect aerial surveys was completed early in the year. The resulting program places top priority on two fields of investigation: methods for determining the trend of tree mortality caused by endemic insect populations, and methods for recognizing damage promptly, while the insects are still in the trees.

Douglas-fir Beetle

An additional study on the photographic evaluation of mortality caused by Douglas-fir beetle epidemics further confirms previous results. Aerial color photos with a 1:5,000 scale and taken after 2 years of heavy mortality provide an accurate evaluation of the total loss. Identification of the most recent year of mortality is also reliable, but not that from the previous year.

Western Pine Beetle

A final analysis of data from a cooperative study in southern California confirms preliminary results previously reported. Vertical aerial color photos at a scale of 1:5,000 proved useful for evaluating mortality caused by a pine beetle epidemic. Trees which were just beginning to fade from recent attacks were easier to spot on the photos than from the ground.

Attempts to improve interpretation accuracy by doubling photo scale and by shifting the viewpoint from the vertical to a 20° oblique were not successful. Hence, 1:5,000 scale vertical color photos remain the best known type of photography for this purpose.

Salvage and Control Planning

We photographed several areas containing heavy insect damage of various kinds. The purpose was to test and demonstrate the usefulness of special aerial photography for planning salvage and insect control operations. Foresters found that both vertical and oblique color photos provided them with an excellent overall orientation of the damage problem. The photos showed the location of the damage in relation to the timber, the topography, and existing roads. Hence, they saved time and field effort in planning timber marking operations, cutting units, and road locations.

PLANS FOR 1962

- Continue development of methods for improving Forest Survey area and volume statistics through supplementary aerial photo plots.

- Begin studies to determine most efficient methods of measuring trends in area and volume statistics.

- Revise photo interpretation training manual for publication.

- Begin studies on use of aerial photos in timber stand improvement and sale preparation.

- Complete data collection and analysis phases of study on photographic assessment of endemic mortality caused by western pine beetle.

Forest Management Research

Division program and organization were modified during 1961 from a "research center" to a "project" framework to focus stronger and more specialized attention on some of the most pressing forest management problems in the Northwest. Of nine active projects, five are aimed toward development of improved silvicultural practices for major forest types: (1) Douglas-fir, (2)spruce-hemlock, (3) mixed-conifer (southwestern Oregon) forests of the "west side," (4) "east-side" forests of ponderosa pine and lodgepole pine, and (5) true fir-mountain hemlock forests of the Coast and Cascade Ranges. An additional four projects are aimed toward solution of urgent regional problems common to several forest types: (6) seeding and planting, (7) forest tree improvement, (8) brush control, and (9) control of animal damage. Recent progress, by projects, is briefly reported in the sections that follow.

DOUGLAS-FIR

Regeneration on Modified Clearcuts

During 1954-55, several experimental cuttings were made in old-growth stands on the H. J. Andrews Experimental Forest to explore whether increasing residual-stand shade would improve environmental conditions for Douglas-fir regeneration. Five patterns of clear cutting were applied:

1. East-west strips, 100 to 300 feet wide
2. North-south strips, 50 to 350 feet wide
3. Small group cuttings, 1/4 to 4 acres in area
4. Seed-tree cutting, 20 acres in area
5. Conventional staggered setting, 40 acres in area.

Old-growth Douglas-firs, spaced at about 100-foot intervals, were left on this cutting area to provide both shade and seed. By the fifth year after cutting, this area supported 1,450 Douglas-fir seedlings per acre compared with 400 per acre on a nearby staggered setting where all trees were cut.

By the fifth year after logging, all four of the modified cuttings were found to be better stocked with natural seedlings than the conventional clearcutting:

Treatment	Plots (milacre) stocked with Douglas-fir (percent)	Douglas-fir seedlings per acre (number)
East-west strips	59 to 81	1,700 to 4,550
North-south strips	31 to 57	550 to 1,450
Group cuttings	29 to 64	450 to 2,300
Seed-tree cutting	50	1,450
Staggered setting	21	400

Tree Size and Tree Value

A recent thinning in a 67-year-old stand of Douglas-fir on the McCleary Experimental Forest illustrates the importance of tree size on value yields from commercial thinnings.

The sale yielded 105,000 board feet of logs (Scribner rule) which were sold to an Olympia sawmill at the following grades and prices:

Grade	Volume (percent)	Price, f.o.b. mill (per M bd. ft.)
No. 3 Sawmill	42	$37.50
No. 2 Sawmill	41	47.50
Suitable for peeling (SFP)	17	60.00

When these prices are apportioned to the harvested stems, tree values by diameter class are as follows:

D.b.h. (inches)	Tree volume Scribner rule (board feet)	Tree value per M board feet, f.o.b. mill (dollars)	Total tree value, f.o.b. mill (dollars)
10	42	37.50	1.60
14	218	37.50	8.20
18	410	47.20	19.35
22	665	52.15	34.70
26	983	54.20	53.30
30	1,334	55.00	73.35

Tree value per thousand remains almost constant up to a diameter of 14 inches because all logs cut from these small trees are graded as No. 3 Sawmill. From 14 to

22 inches d.b.h., tree value per thousand increases rapidly as more No. 2 Sawmill and SFP (suitable for peeling) log grades are produced. Above a diameter of 22 inches, rate of value increment again tapers off rapidly because logs produced from these larger trees are graded No. 2 Sawmill and SFP in about equal proportions.

When both value and volume increment are taken into account, the increased returns from growing trees to a diameter of 22 to 24 inches appear to be substantial.

Third Commercial Thinning in a Plantation

Three thinnings at 5-year intervals have been completed in the 36-year-old Snow Creek plantation on the Olympic National Forest. In all three intermediate harvests, dead and dying trees were salvaged and least desirable competitors removed. Tree-length logs were skidded to roadside with horses and bucked into pulpwood bolts. Bolts were loaded by hydraulic lift and trucked 31 miles to a paper mill in Port Angeles. Cumulative yields from the three periodic thinnings total 1,900 cubic feet per acre.

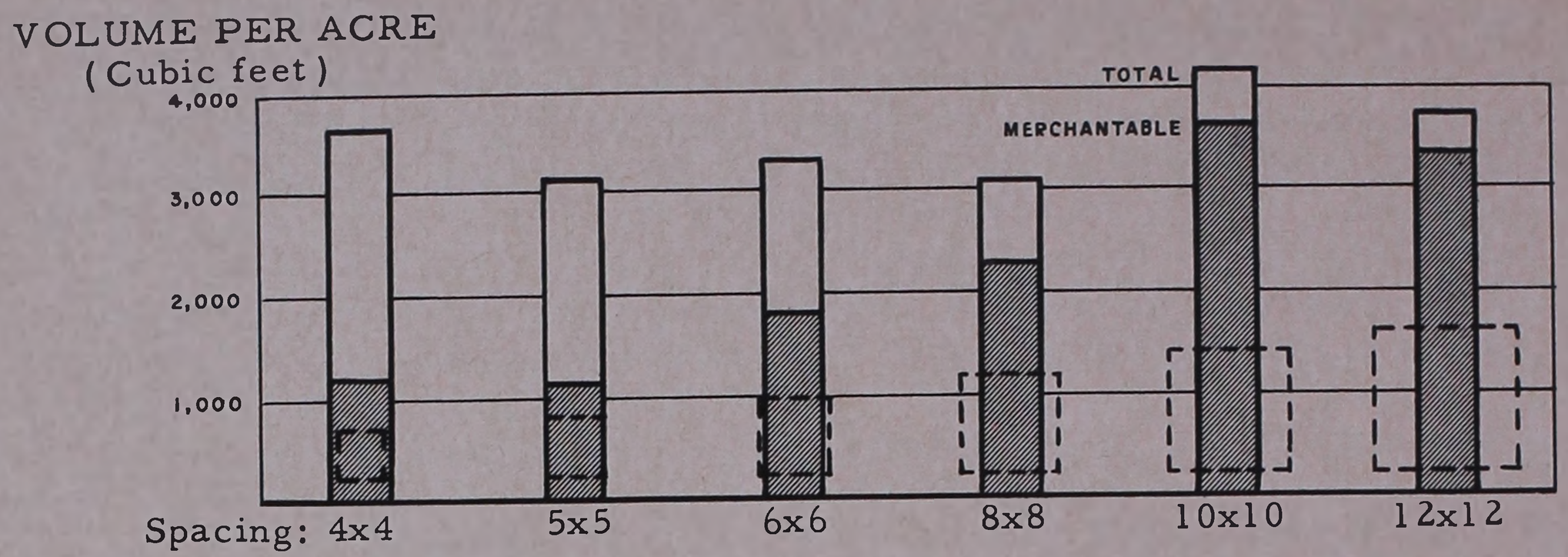
The residual stand now contains 270 well-spaced, vigorous trees per acre with a volume of 4,400 cubic feet in trees averaging 10 inches d.b.h. An adjacent, unthinned portion of the plantation contains 470 stems per acre with a volume of 6,200 cubic feet in trees averaging 9 inches d.b.h. Losses in the unthinned stand have averaged 80 stems per acre for the last decade. Since gross increment in the thinned stand has exceeded that in the unthinned during the past 5 years, the thinnings in the plantation have apparently succeeded in transferring the full growth capacity to fewer stems.

Initial Spacing in Plantations

The spacing plantations at Wind River Experimental Forest were remeasured in 1960 at age 36. The new records confirm earlier trends which had demonstrated that average height and average diameter both increase markedly as initial spacing is widened from 4x4 to 12x12 feet.

Total volume (all trees 1.5 inches d.b.h. and larger--entire stem) now varies from roughly 3,000 to 4,000 cubic feet per acre among the six spacings, but is apparently independent of initial spacing. In contrast, merchantable volume (trees 5.6 inches d.b.h. to a 4-inch top) varies from about 1,100 to 3,600 cubic feet per acre and is strongly related to initial spacing. The 10x10 and 12x12 plantations now contain about three times as much merchantable volume as the 4x4 and 5x5 spacings.

Expressed another way, the proportion of total cubic volume currently merchantable ranges from 33 percent in the 4x4 spacing to 90 percent in the 12x12 spacing.



Effect of initial spacing in Douglas-fir plantations on total and merchantable cubic-foot volumes at age 36, site class IV.

Release and Branch Elongation

A study of 3 unreleased and 29 released trees in the 50-year-old Douglas-fir stand at Voight Creek Experimental Forest indicated that release tends to reduce rather than accelerate branch elongation during the first few growing seasons after thinning. This effect was most pronounced in the upper part of the crown. Moreover, when released and unreleased sides of a single tree were compared, no differences in branch elongation were apparent. Diameter growth of all released trees showed a positive response to thinning. Thus, crown buildup is apparently not a major contributing factor in the initial stem-growth response of released trees.

Snow Damage in Thinned and Unthinned Stands

A storm in late November 1960 left some 6 inches of heavy, wet snow in many parts of western Washington. Many forest trees were broken, knocked over, or badly bent.

A check of 50-year-old Douglas-fir stands at Voight Creek Experimental Forest showed that damage was much more severe in the unthinned than in thinned compartments:

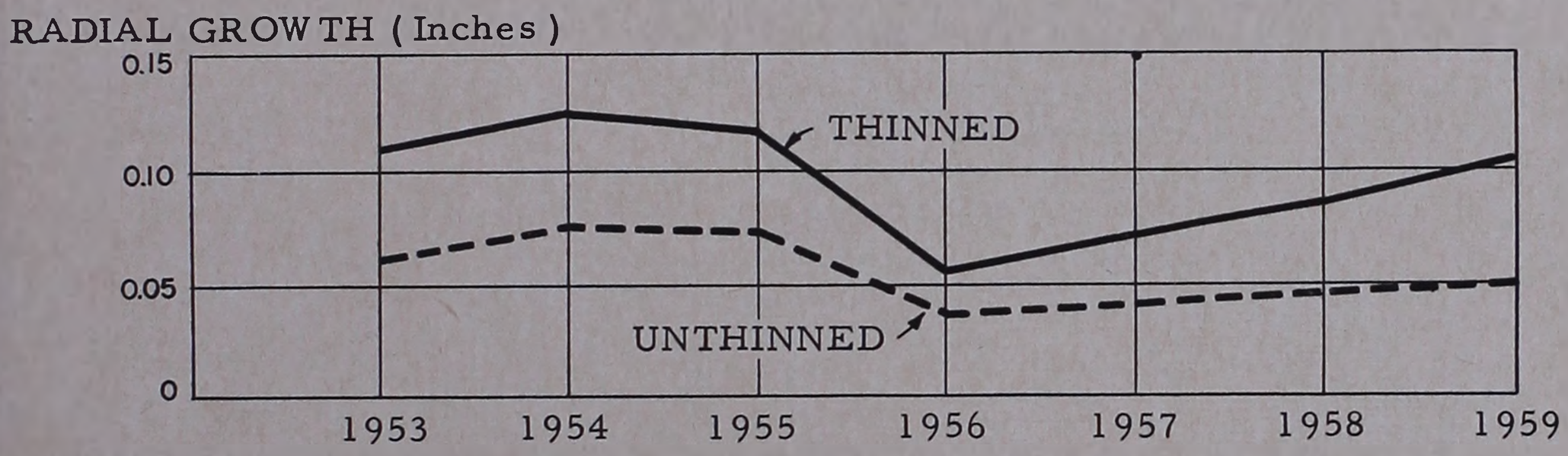
Type of damage	Compartment-- A-1 thinned	A-3 thinned	A-2 unthinned
	(number of trees per acre)		
Trees bent	10.9	8.7	14.0
Trees broken	10.0	6.7	32.6
Trees knocked down	1.3	2.7	4.0
Total	22.2	18.1	50.6

In the thinned stands, most of the damaged trees were in the 4- to 6-inch diameter classes and not of merchantable size. In contrast, about half of the damaged trees in the unthinned compartment were in the more valuable 8- to 12-inch diameter classes.

Freeze Damage in Thinned and Unthinned Stands

The freeze of November 1955 seriously damaged forest trees as well as ornamental trees and shrubs in many parts of the Northwest. Large numbers of native forest trees were killed outright. Countless others were injured but survived. A measure of the effects of such injuries on diameter growth and volume increment is provided by records from 50-year-old stands of Douglas-fir on the Voight Creek Experimental Forest.

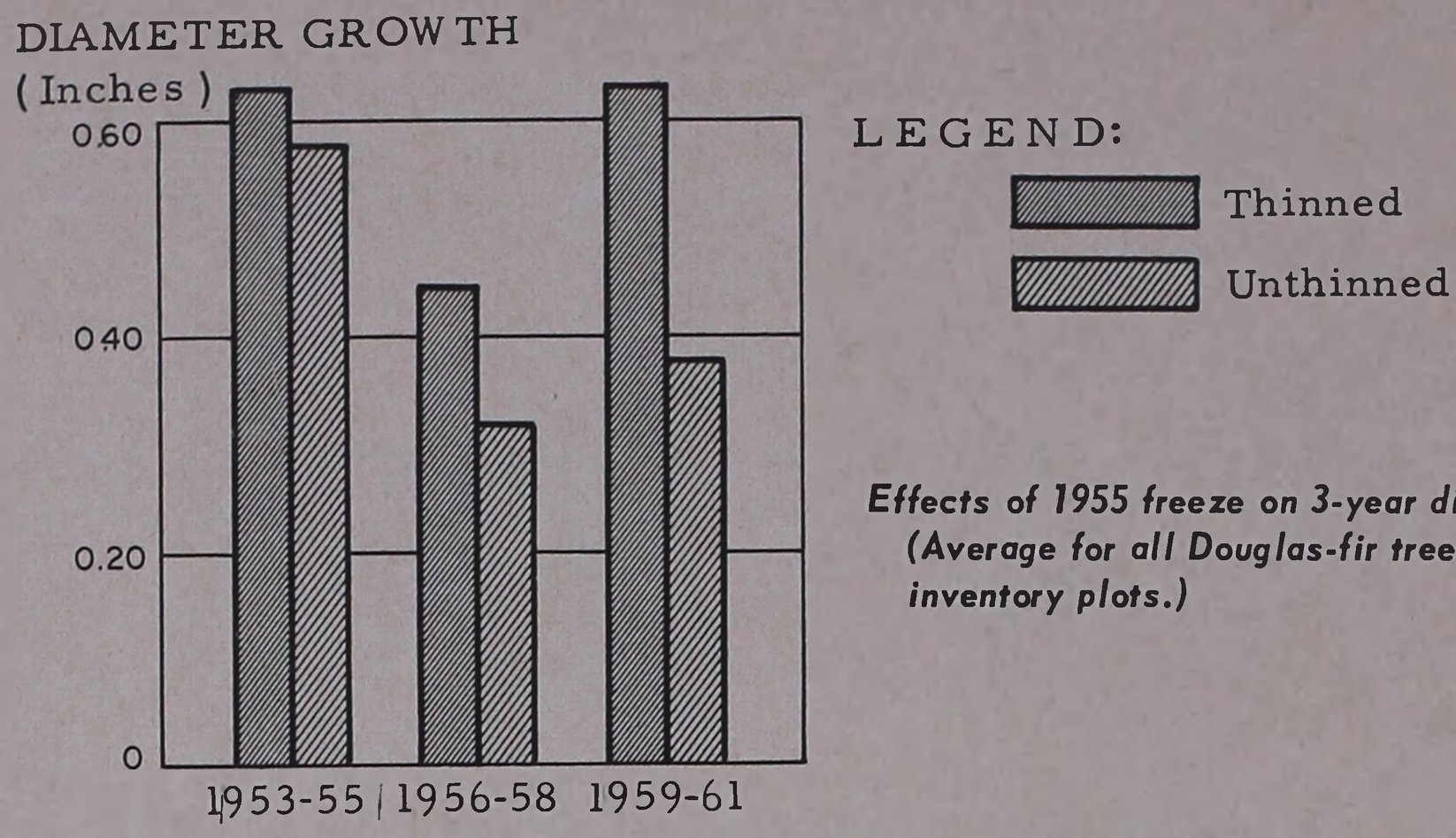
Annual radial growth was determined for 14 felled and dissected codominant trees--3 from an unthinned stand and 11 from a thinned stand. These show that in 1956 (first growing season after freeze) average radial growth dropped sharply to about half the 1955 rate. During the following three growing seasons, radial growth consistently improved but approached the prefreeze level only in thinned stands. For most trees, growth reduction and gradual recovery were fairly uniform throughout length of stem.



Effects of 1955 freeze on annual radial growth at d.b.h. of dissected codominant trees in a 50-year-old Douglas-fir stand.

The same trends are apparent when average diameter growth of all trees on selected inventory plots for a 3-year period before the freeze is compared with that for two 3-year periods since the freeze. For the first period after 1955, diameter growth was 30 percent below the prefreeze level in thinned stands and 45 percent in unthinned. In the second period, diameter growth returned to the prefreeze level in thinned stands but made only a limited recovery in unthinned.

Cubic-volume increment in both thinned and unthinned stands dropped to about two-thirds of the prefreeze level during the first 3 years after the freeze.



Effects of 1955 freeze on 3-year diameter growth. (Average for all Douglas-fir trees on selected inventory plots.)

SITKA SPRUCE–WESTERN HEMLOCK

Skyline-Crane Yarding

The initial test of skyline-crane yarding at Cascade Head Experimental Forest was completed early in the year. Using a Skagit radio-controlled Sky Car, 3 million board feet of 110-year-old Sitka spruce and western hemlock logs were yarded from a steep 35-acre clearcut. This first small yarding unit was selected by the Station and our cooperators--Publishers' Paper Co.--to provide crew training and equipment shakedown. We used four skyline roads with yarding distances of 2,000 to 2,700 feet. No intermediate supports were required for the skyline. Lateral yarding distances on either side of the skyline ranged up to 150 feet. Using a yarding crew of six men, log production was:

Net volume per acre		85,000 board feet
Net volume per turn		1,146 board feet
Average turns per hour		5.1 turns
Operating days		
Rig-up	16	
Yarding (including minor delays)	78	
Down time (mechanical and weather)	31	
Total		125 days
Average production per yarding day (7.5 hours with no delays)		43,835 board feet
Average production per operating day		23,800 board feet

Initial cost of experimental equipment was $91,093. Direct yarding costs per thousand board feet averaged:

Moving and rigging	
Labor	$1.48
Supplies	.12
Operating	
Labor	4.78
Supplies	1.80
Maintenance and repair	
Labor	.18
Supplies	.26
Construction of ridgetop tractor road (to bring in snubber)	.67
Total	$9.29

A clear-cut, 35-acre logging unit after skyline-crane yarding was completed. Note scarcity of broken logs and absence of evidence of soil disturbance.

Sample Scaling

Cost of truck scaling all logs from a harvesting operation is sometimes excessive and out of proportion to total value of timber cut. Cost of scaling includes not only the scaler's salary but also delay time of log truck and driver while logs are scaled, which can be equally important. A recent study at Cascade Head Experimental Forest illustrates a situation where sample scaling of truck-loads should provide a substantial saving.

In this case, 80 of 610 truckloads from a single harvesting operation were sampled and scaled. Logs were young-growth Sitka spruce and western hemlock cut from a uniformly aged, 110-year stand.

Stumpage was $3.95 per thousand board feet. Through the sample scale, total stumpage value for the unit was estimated at $11,747. Statistical analysis indicated the true sale value was between $11,131 and $12,363 unless a 1-in-20 chance occurred during sampling. Therefore, the chance was 19-in-20 that logs were sold for a sum within $616 of the total value that would have been realized if all loads had been scaled.

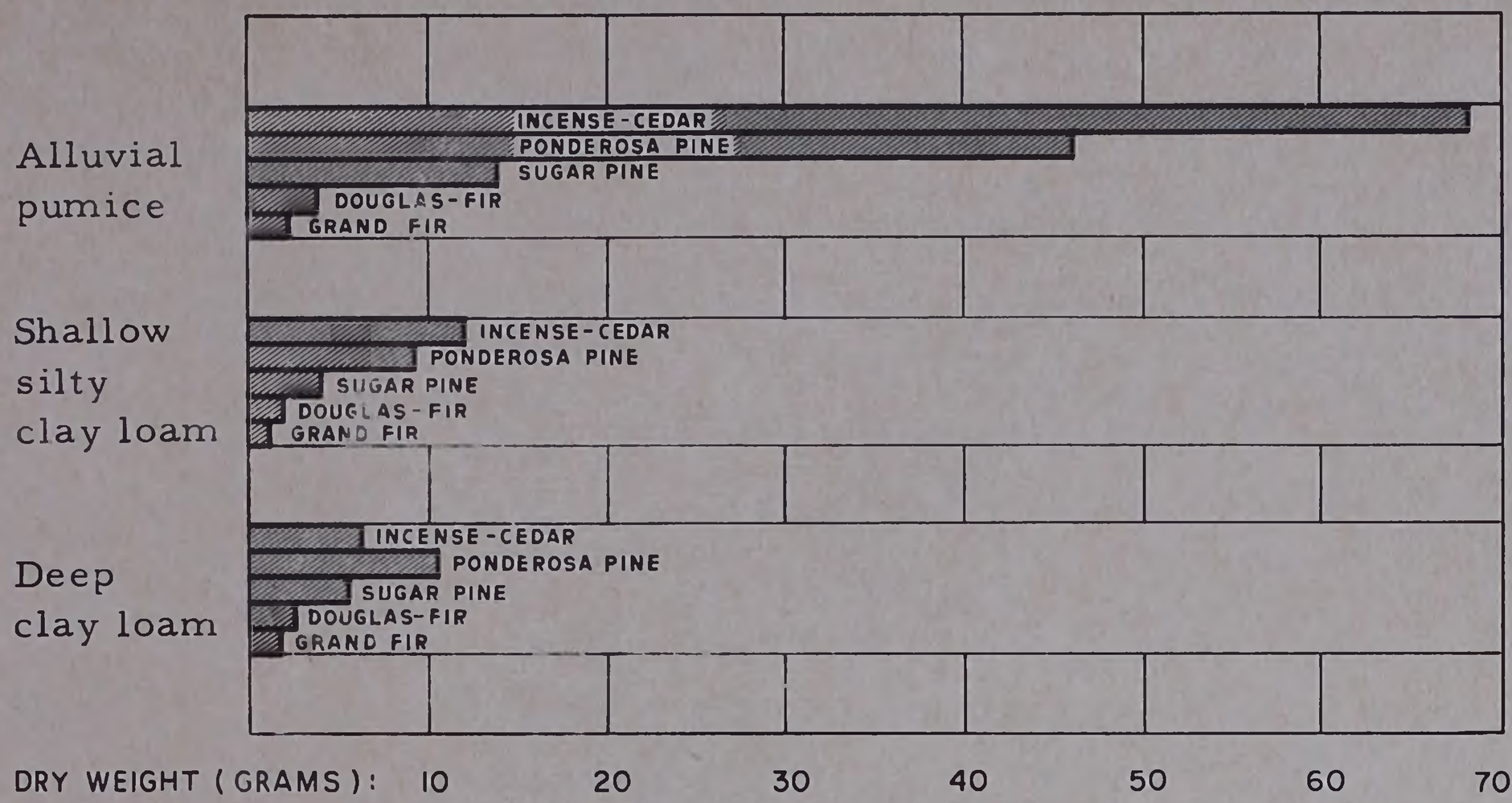
Since trucks are idle an average of 16 minutes during scaling, a total of 8,480 minutes of truck waiting time would have been required to scale the additional 530 loads. At $0.09 per minute, this waiting time represents a cost of $763. Direct scaling cost at $0.30 per thousand board feet would add an additional $775 to the scaling cost for a total of $1,538. Theoretically, costs were thus reduced about $1,538 on this operation through sample scaling. When this saving is weighed against a maximum possible gain or loss from sample error of only $616, the use of sampling appears to be fully justified.

MIXED CONIFERS

The mixed-conifer zone of southwestern Oregon covers almost 4 million acres and contains varying mixtures of sugar pine, Douglas-fir, ponderosa pine, incense-cedar, and grand fir. A highly variable and complex pattern of vegetation, climate, and soil presents a large number of challenging problems to the forest manager. One major study, now in its final phases, is a comparison of the juvenile development of five conifers.

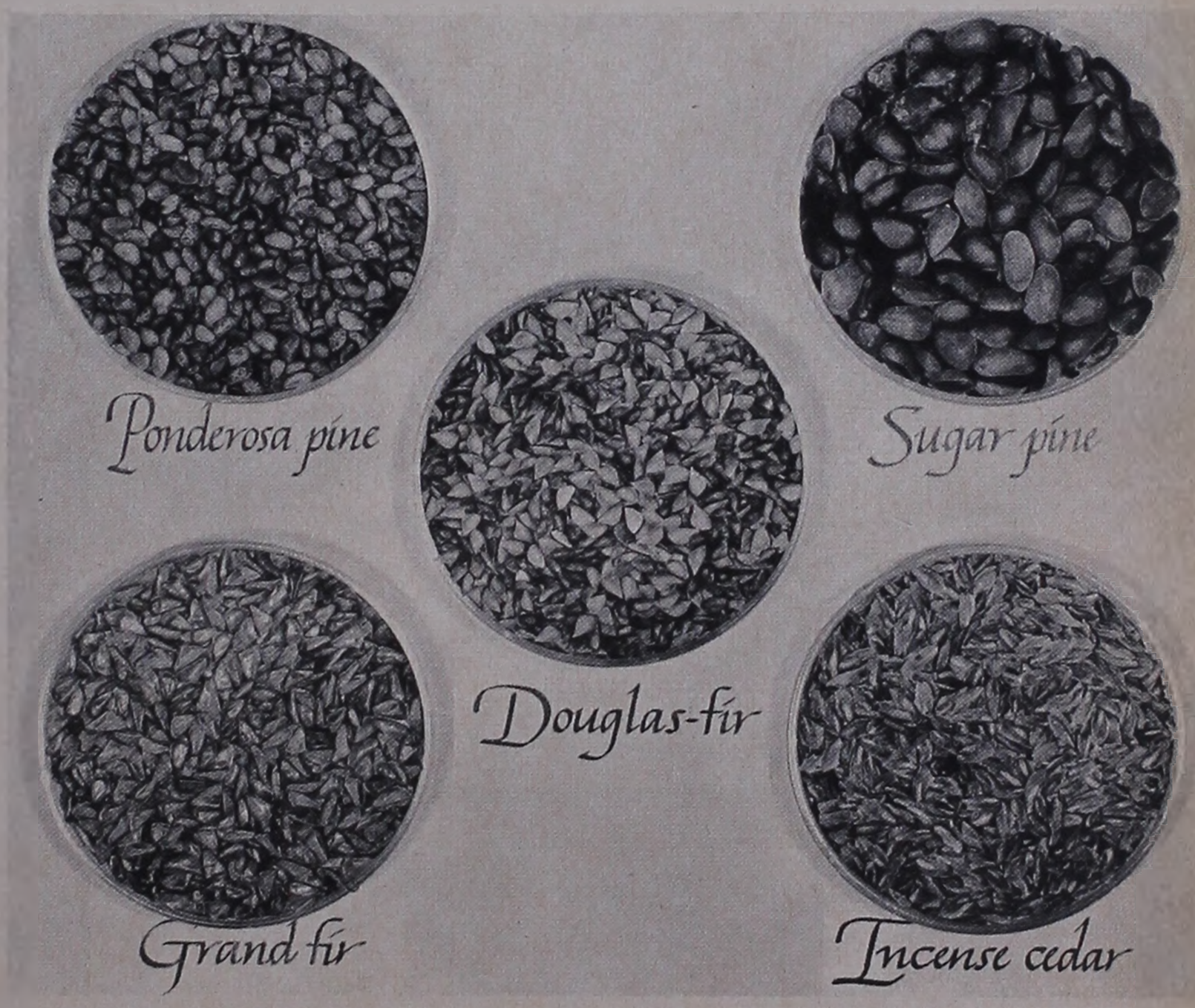
Dry Matter Production Among Five Conifers

At the end of the second growing season, total production of dry matter differed markedly among the five species of conifers grown from seed on three typical soils. On two soils--alluvial pumice and shallow silty clay loam--incense-cedar produced substantially more dry matter than ponderosa pine, sugar pine, Douglas-fir, or grand fir. On deep clay-loam soil, ponderosa pine was heaviest and incense-cedar second. Sugar pine was third heaviest on all three soils, with Douglas-fir fourth but not differing significantly from fifth-place grand fir.



Average total dry weight of 2-year-old seedlings grown on three southwestern Oregon soils.

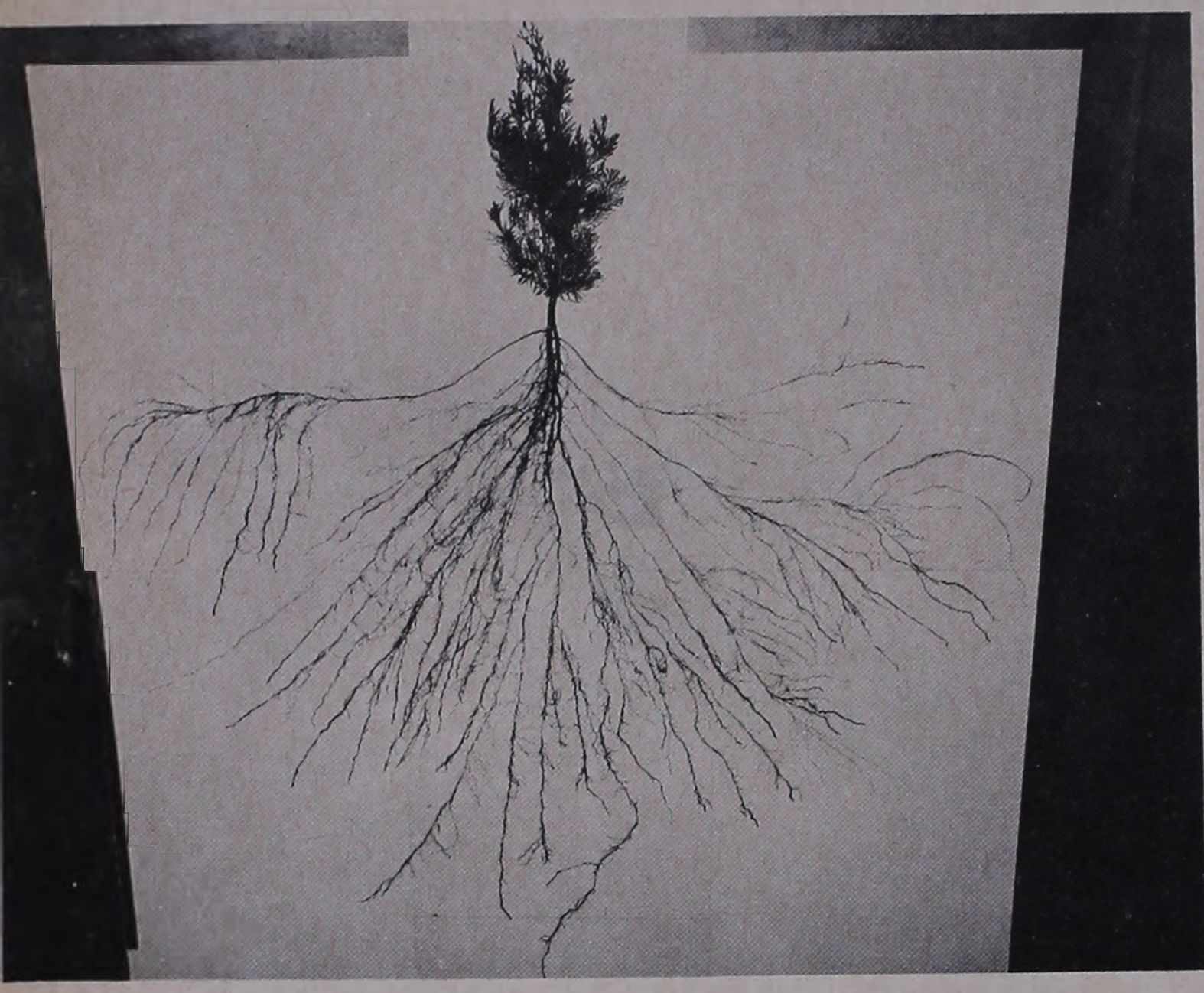
Dry matter production was not related to either seed size or size of newly germinated seedlings. Right after germination, sugar pine, with the largest seed, produced seedlings double the weight of ponderosa pine, the second largest. In contrast, incense-cedar with relatively light seed and initial seedlings made faster growth, particularly in the second year.



Comparative seed size of five southwestern Oregon conifers.

For all species, dry matter production was much higher during the second growing season than the first. Incense-cedar was 10 to 18 times heavier at 2 years than at 1. Ponderosa pine was 8 to 16 times heavier and the other three species weighed 4 to 6 times more.

The great differences in dry matter production among species must be due to differences in photosynthetic efficiency. Whether these differences result from more efficient use of sunlight, better absorption and translocation of soil moisture and nutrients, superior rooting characteristics, or a combination of these factors remains to be determined. In excavating the seedlings, it was obvious, however, that incense-cedar and ponderosa pine had developed root systems that occupied the soil more extensively and uniformly than the other three species.



Excavated seedling of incense-cedar after two growing seasons in alluvial pumice. The finely divided and extensive root system fully penetrated a large volume of soil.

EAST-SIDE FORESTS

Site Index, Lodgepole Pine

Stand density exerts a pronounced effect on height growth of lodgepole pine. As a result, the conventional height-age relationship fails to provide an accurate index of site quality.

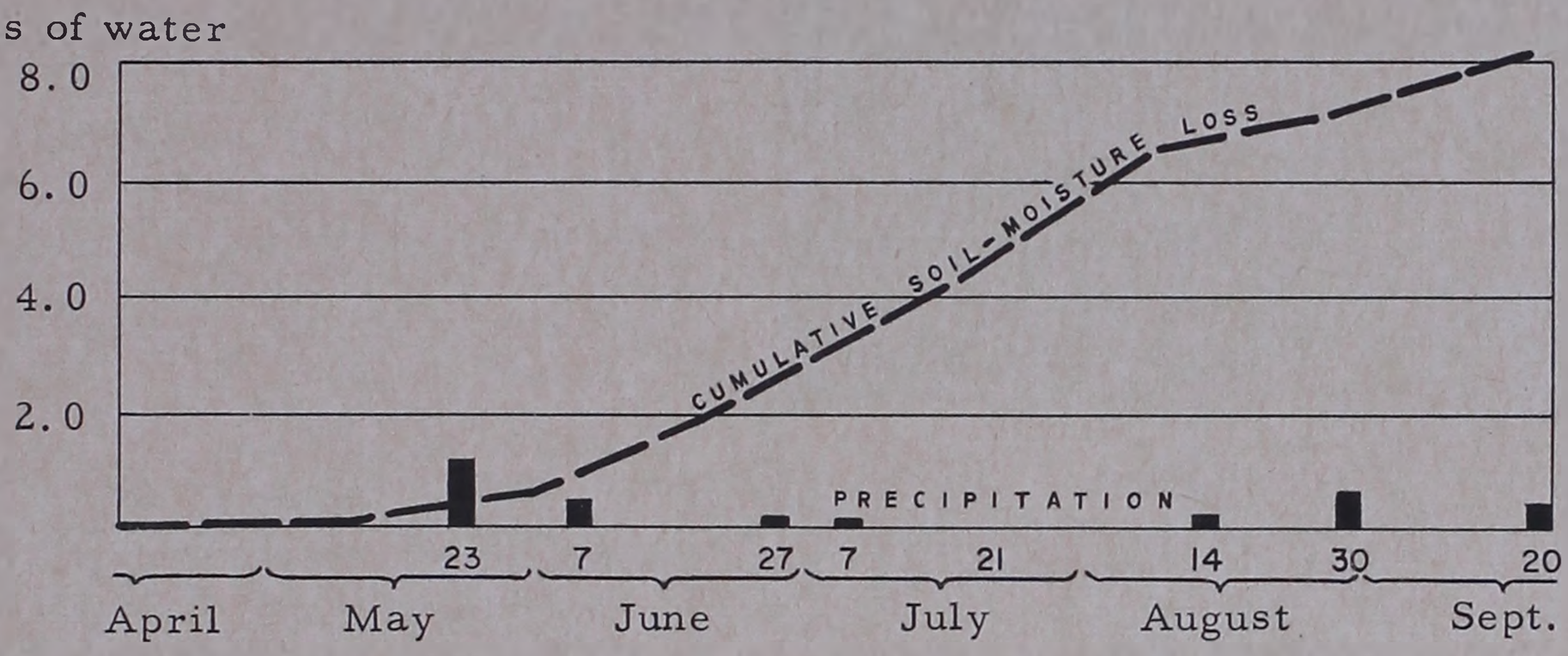
Through cooperation with the Intermountain and Rocky Mountain Stations and with research foresters in Alberta, Canada, a joint effort was begun in 1961 to develop a height correction for stand density that can be applied interregionally.

A crown-competition formula for measuring stand density has been devised, tested, and found to fit data from the widely separated regions remarkably well. Final objective is a new site-index system that can be satisfactorily applied to lodgepole pine throughout its range.

Soil Moisture in Thinned Lodgepole Pine

Soil moisture was measured at short intervals throughout the growing season under recently thinned stands of lodgepole pine in pumice soils on the Deschutes plateau in central Oregon. All measurements were made with a neutron probe furnished through cooperation of the Soils Department, Oregon State University.

Early in the season, surface soil showed the most striking reduction in moisture content. Later in the season, however, substantial reductions occurred more than 5 feet below the surface. For the entire record period (April 14 to September 18) an average of 8.1 inches of water was removed from the upper 10 feet of soil.



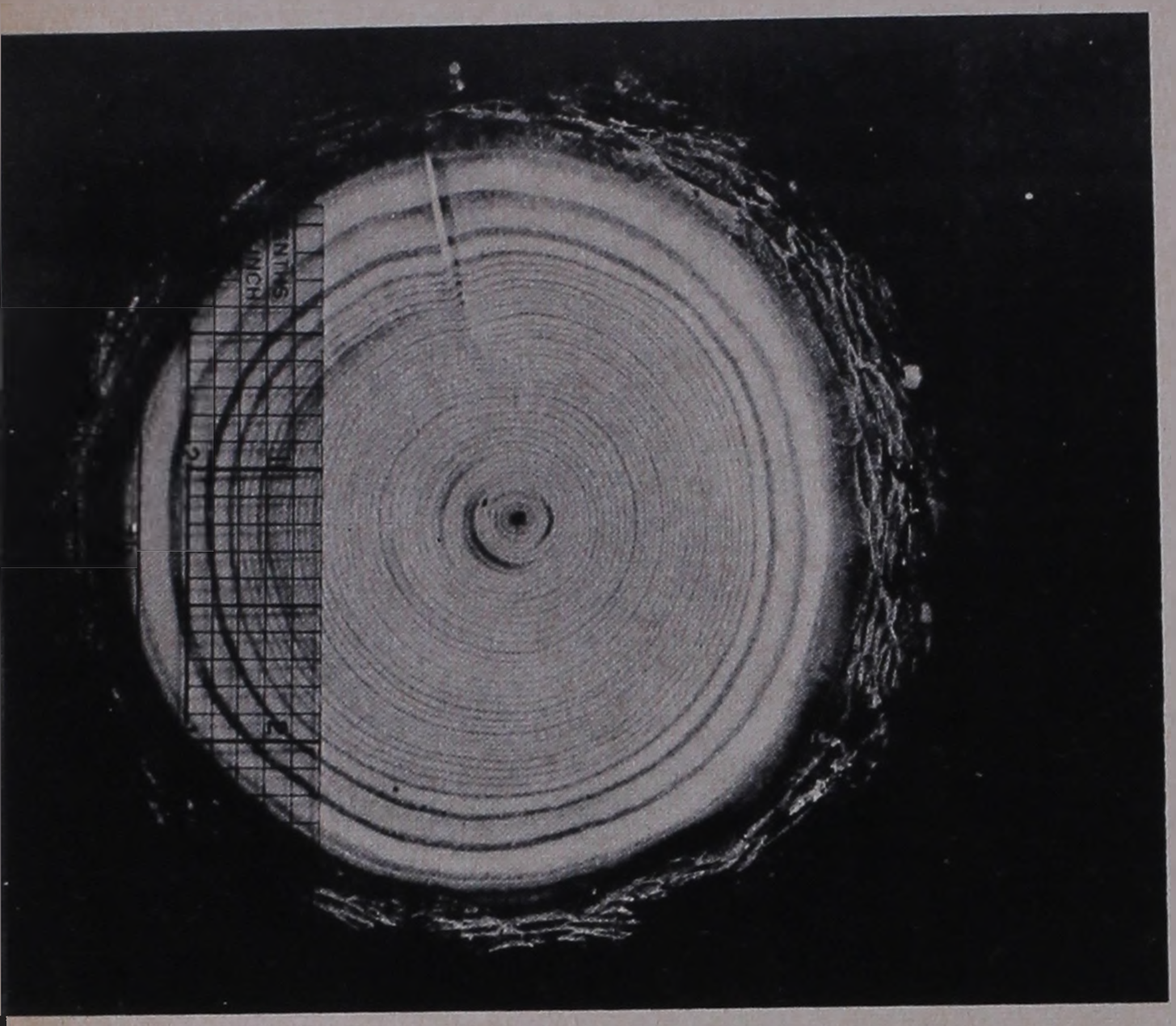
Precipitation and cumulative net soil-moisture loss in upper 10 feet of soil under thinned stands of lodgepole pine in central Oregon.

A comparison of records from lightly and heavily thinned stands further showed that the greatest reduction in soil moisture content took place where more stems were left.

Response of Ponderosa Pine Saplings to Release from Overstory and Thinning

When we installed our ponderosa pine spacing study at Pringle Falls Experimental Forest 4 years ago, a long-suppressed dense stand of saplings was first released from all overstory competition and then thinned to spacings varying

from 7 to 26 feet. Recent observations show that response of saplings to release has been prompt and spectacular. Trees that had attained a diameter of only about 3 inches during 40 to 70 years of suppression are now putting on annual rings one-fourth inch wide. In many instances, needle length has also doubled since additional growing space was provided.



Typical diameter-growth response of ponderosa pine saplings released and thinned 4 years ago.

Needle length before and after thinning. Longer needles were produced after release.

Spruce Budworm Defoliation and Tree Growth

Three primary tree hosts of the budworm in northeast Oregon--Engelmann spruce, grand fir, and Douglas-fir--occur in mixed, uneven-aged stands along with ponderosa pine. Stem analyses of some 100 individual trees have recently shown that impact from defoliation on volume growth can be estimated by classifying trees into four damage classes varying from I (trees showing little or no evidence of defoliation) to IV (trees apparently dying and with over 50 percent of branches dead).

During a 5-year-damage period, class II trees of grand fir produced 77 percent as much volume as undamaged or class I trees. Class III trees produced only 66 percent as much volume during the same period. Predamage growth rates for all four classes were about on a par. Grand fir was most severely damaged, Douglas-fir was least damaged, and Engelmann spruce was intermediate.

Douglas-fir of spruce budworm damage class I (left) growing in close proximity to two grand firs, both damage class IV (center and right).

TRUE FIR—MOUNTAIN HEMLOCK

In midyear, the staff for this relatively new project was increased from one to two scientists. First efforts have been directed to regeneration problems, with emphasis on three key species--noble fir, Pacific silver fir, and mountain hemlock.

A cone production study for these species, plus western white pine, was begun with sampling points widely distributed throughout the Cascade Range. For noble fir, a cone maturity study was also carried out to find a practical index to seed ripeness and to determine relation of viable seed yield to time of collection and method of storage.

In addition, an annotated bibliography on noble fir was completed and will be released early in 1962. Bibliographies for Pacific silver fir and mountain hemlock will follow.

SEEDING AND PLANTING

Tree Seeds and H_2O_2

Several scientists have noted that seed germination is stimulated by soaking seed in a weak hydrogen peroxide solution (1 percent or less). In searching for an improved technique for sterilizing seedcoats, we learned that a strong hydrogen peroxide solution (35 percent) can be used effectively not only to provide aseptic seed but also to stimulate germination. Concentrated hydrogen peroxide is, of course, lethal to living material; but not enough of the chemical reaches the seed embryo in 1/2 to 2 hours of soaking (depending on thickness and permeability of seedcoat) to cause damage. Seed germination of several conifers, including Douglas-fir, ponderosa pine, Sitka spruce, and western hemlock, is markedly hastened by treatment with strong H_2O_2.

A Highly Adaptable Mycorrhizal Fungus

Cenococcum graniforme forms mycorrhizae on roots of a very large number of trees, including species of Pinaceae, Betulaceae, Fagaceae, and Salicaceae families. Recent field studies show it occurs throughout the altitudinal range of trees in the Northwest, from pioneering trees on Oregon coast sand dunes to stunted shrubs far above timberline in the Cascade Range. C. graniforme was also found growing under very adverse conditions where most other mycorrhizal

Cenococcum graniforme is found abundantly in habitats as widely diverse as: Sitka spruce on stabilized beach dunes (below); high-site, virgin Douglas-fir (left); ponderosa pine at edge of central Oregon desert (opposite page); and subalpine larch at timberline (far right, opposite page).

fungi cannot survive. It occurs abundantly not only on cold alpine sites but also in dry zones of eastern Oregon where forest merges into desert. It has even been found on poorly drained sites that are waterlogged much of the year. Examination of soil samples from other regions demonstrates that this fungus has an extremely wide range geographically--from tropical Puerto Rico to far above the Arctic Circle in Alaska.

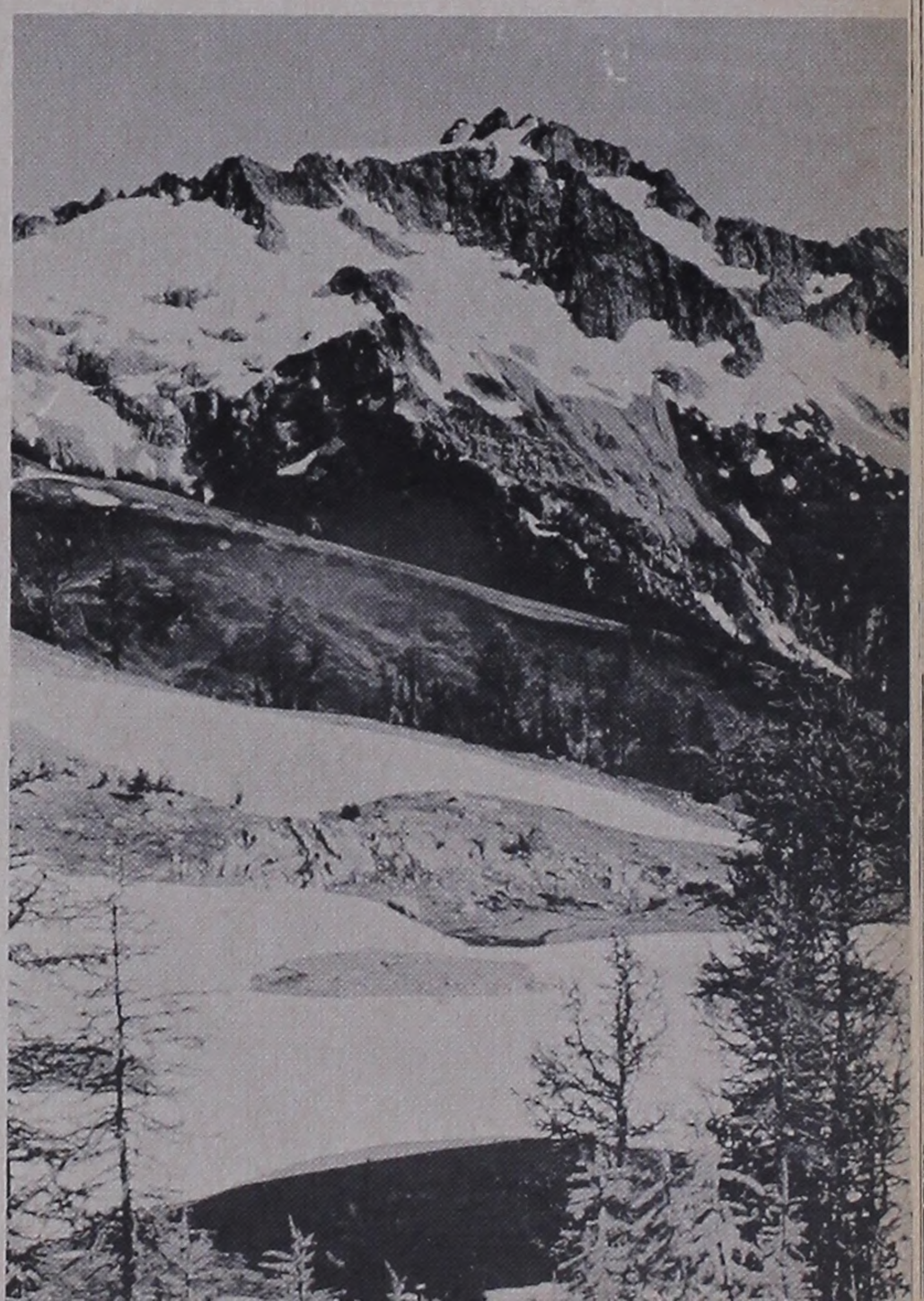
FOREST TREE IMPROVEMENT

Seed Orchard Technology

Cooperative studies with the Olympic National Forest on the Dennie Ahl Seed Orchard near Shelton, Wash., have shown that for Douglas-fir:

1. Incompatibility between scion and rootstock can show up the second year after grafting. About one-sixth of those grafts considered successful at the end of the first year died during the second year.

2. Production of female cone buds can be altered significantly by soil or foliar applications of fertilizer. Where a 20-10-10 fertilizer was applied in the spring to soil around trees 5 to 10 feet tall, those receiving 1/2 to 3 pounds per tree averaged 125 female buds per tree the following fall, compared with 100 female buds for trees receiving 5 pounds of fertilizer, and no female buds for unfertilized trees. Foliar application of a balanced fertilizer in the spring increased the formation of female buds the following fall by about seven times.



3. Normal reproductive cycle can be altered by removal of female cone buds in the spring. During 1961, removal of all cone buds on selected trees increased by three times the set of the 1962 crop of female cone buds.

These findings indicate that cone production may possibly be postponed from a year of heavy pollen production in natural stands to a year of lighter pollen production (and lower hazard from pollen contamination). In both bud removal and fertilizer studies, treatments were most effective when carried out prior to time of vegetative bud bursting.

Genetic Variation--Douglas-fir

Our provenance study of Douglas-fir, now 48 years old, continues to provide information on how far planting stock should be moved from its seed source. The study consists of progeny of 120 parent trees from 13 localities established in 5 plantations at elevations from 1,100 to 4,600 feet. Important new findings are:

1. Seed origin is more critical in high-elevation (above 2,000 feet) than in low-elevation plantations. At the 1,100-foot-elevation plantation, which was also the most favorable site, no differences in volume growth per tree among parents or source localities could be detected. At higher elevations (where environmental stresses were more severe) differences in volume growth per tree among the 13 source localities were pronounced.

2. Superior performance of a given geographic seed source at one planting site provides no assurance of superior performance at another site. In fact, each locality source that showed superior performance in one plantation performed relatively poorly at one of the other four.

3. Within a given plantation, good volume growth of a progeny was usually associated with good survival. Since each row of trees is from a single female parent, low survival would theoretically provide more growing space for survivors. But low-survival progenies failed to respond to more liberal growing space.

4. Slenderness or stockiness of progeny was consistently related to its individual female parent on all plantations. Mortality resulting from the severe freeze of November 1955 was also related to the individual parent.

BRUSH CONTROL

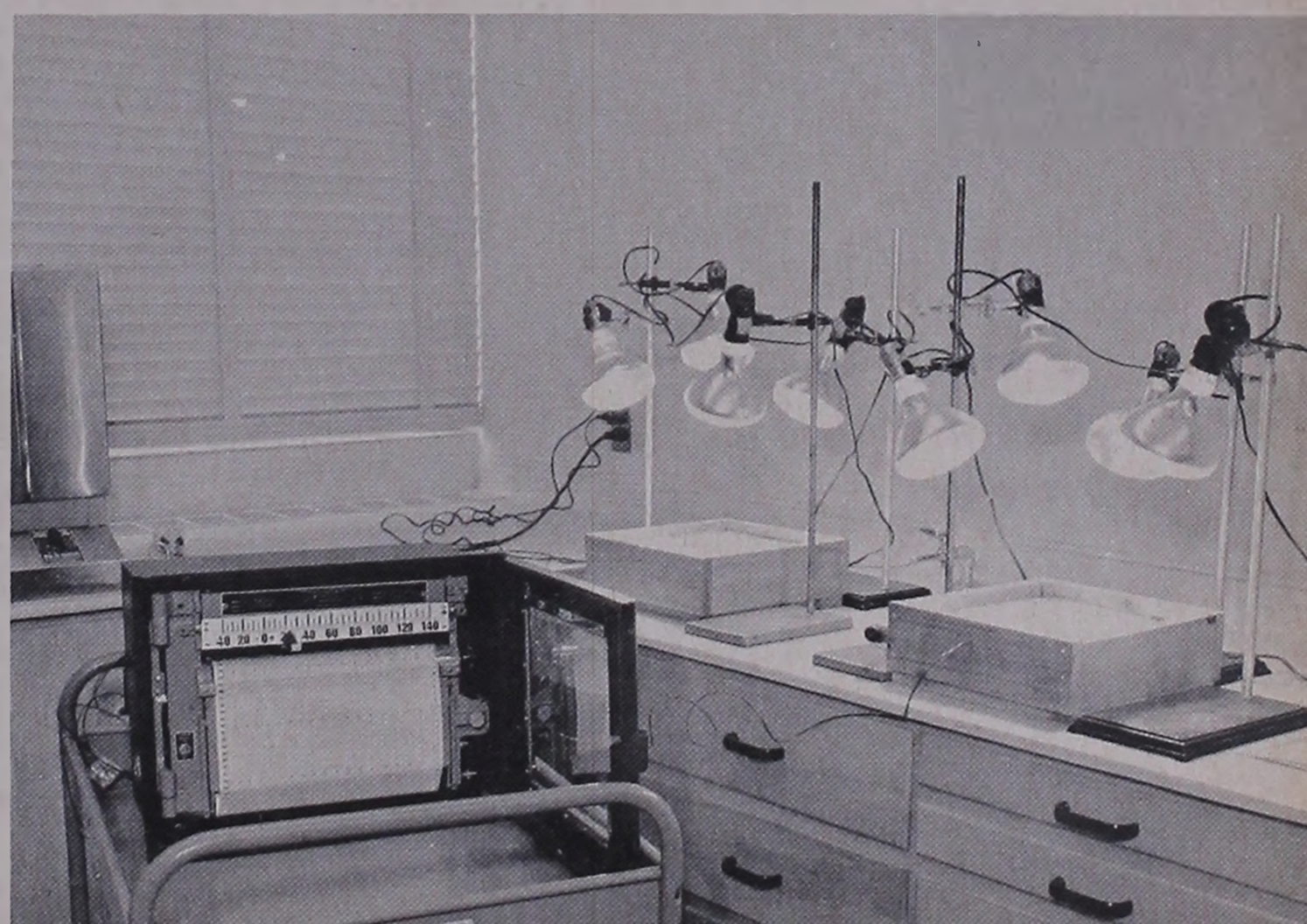
In southwestern Oregon, dense stands of varnishleaf ceanothus often develop after logging and broadcast slash burning in old-growth Douglas-fir forests. Origin of the ceanothus has posed a mystery to foresters, because the parent plants rarely occur in the understory vegetation prior to logging. Soil sampling and laboratory and greenhouse studies now provide evidence that soil under these virgin stands often contains viable ceanothus seed in large numbers--seed produced a tree generation ago which has lain dormant in the surface soil two centuries or more. These studies further indicate that dormancy of this seed can be broken by the heat provided when a broadcast fire burns through logging slash.

Fire, Heat, and Ceanothus Germination

In a laboratory study, 600 ceanothus seeds were planted one-eighth to one-quarter inch deep in each of six flats containing a fine sandy soil enriched with clay. One-half of each flat was covered with a 6-inch layer of excelsior which was then burned to ash. Wooden barriers, sheet metal shields, and aluminum foil covers were used to minimize heat transfer from burned to unburned portions of each flat. As shown in the following tabulation, subsequent germination was over nine times higher in the burned treatment:

Treatment	Seeds germinating (number)	Germination (percent)
Burned	305	17
Unburned	32	2

As a next step, the forest floor and mineral soil on two proposed cutting units in the North Umpqua drainage were sampled to determine occurrence and distribution of dormant ceanothus seed. No parent ceanothus plants were present under the old-growth Douglas-fir overstory on either unit. Although no ceanothus seed was found in the litter and humus layers, 40 percent of surface mineral soil samples contained the seeds. When these were planted in flats, no



Soil samples were heat treated in the laboratory to induce germination of dormant varnishleaf ceanothus seed.

germination took place after an initial period of 2-1/2 months in a greenhouse. But when the flats were later heated to a temperature of 80° C. (at seed depth) then stratified for 2 months and returned to the greenhouse, germination was rapid and produced the equivalent of 131,000 ceanothus seedlings per acre.

Slash Disposal and Ceanothus Germination

After the two logging units used for the study just described had been logged, three slash disposal treatments were applied--broadcast burn, pile and burn, and no burn. As shown in the following tabulation, many more ceanothus seeds germinated after a broadcast burn than after slash was piled and burned, even though the percentage of ceanothus-stocked plots was equal:

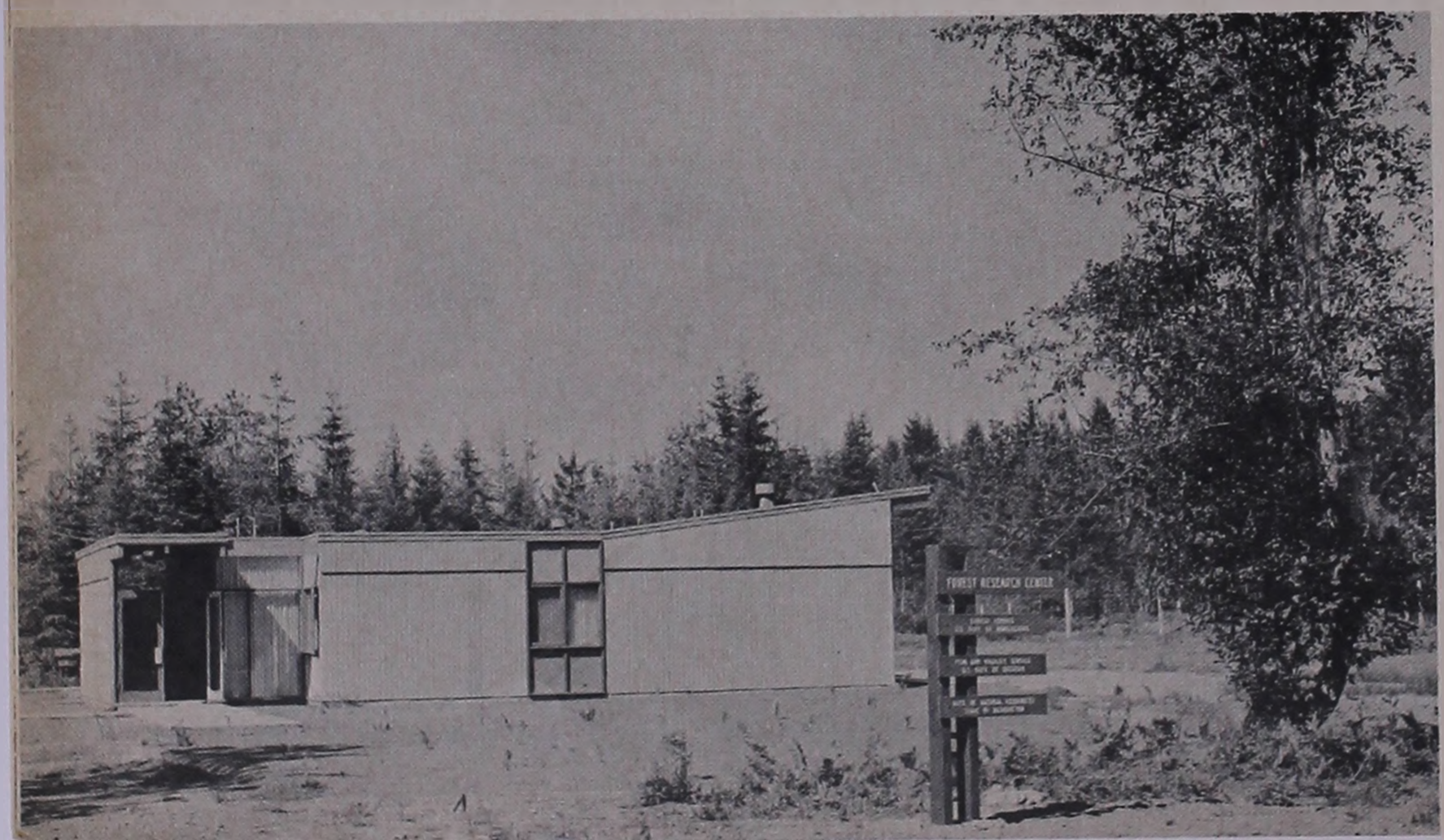
Treatment	Plots (1/5,000 acre) stocked (percent)	Seedlings per stocked plot (number)	Seedlings per acre (number)
Broadcast burn	19	6.5	6,125
Pile and burn	19	1.9	1,750
No burn	8	1.3	500

Where slash was not burned, less than half as many plots were stocked with ceanothus seedlings as in the other two treatments. Total number of seedlings per acre was also greatly reduced.

ANIMAL DAMAGE

The first unit of the Forest Research Center near Olympia was completed late in 1960 to house our new animal damage project which is conducted cooperatively with the Fish and Wildlife Service, U.S. Department of Interior, and the Department of Natural Resources, State of Washington.

A plant physiologist was added to the staff in midyear to initiate the project, and a 3-room plant physiology laboratory has been equipped for



Cooperative animal-damage laboratory near Olympia--the first wing of a proposed office-laboratory to house all station projects in the Olympia area.

biochemical and radiochemical research. Plant physiology phases of the program will include (1) physiological responses of trees or tree seedlings to various kinds and degrees of animal injury, (2) biochemical factors that attract animals to plants, and (3) evaluation and development of direct and indirect methods of damage control.

PLANS FOR 1962

- Strengthen research efforts in three areas of regionwide concern--animal damage, forest genetics, and forest measurement--as far as available funds, personnel, and facilities will allow.

- Bring to publication stage several major manuscripts including (1) "Red Alder--Its Management and Utilization," (2) "Yield of Even-Aged Stands of Western Hemlock," and (3) "Potential Yields of Lodgepole Pine."

- Complete final plans for construction of a silviculture laboratory at Bend, Oreg.

Forest Utilization Research

Our research in forest products utilization is closely associated with research of the Forest Products Laboratory and with a newly developing program of engineering research in the Forest Service. The overall aim of these coordinated programs is to procure more economical use of all available wood--through a better understanding of timber quality, improved harvesting, more effective integration in processing, and greater product serviceability--without seriously impairing watershed, recreation, forage, or wildlife values of forest lands.

During 1961, utilization research at the Station was devoted chiefly to studies of timber quality and of performance of wood in use. Research on timber quality was directed toward developing log and tree grades, improving the basis for timber appraisals, and refining techniques used to determine properties of wood. A plan was developed for considerably expanded research on the performance of wood. It is expected that this comprehensive plan will be implemented by the Station over the next several years.

TIMBER QUALITY

Log and Tree Grades

The Forest Service is conducting a nationwide program of research to develop adequate log and tree grading systems for all commercial timber species. At this Station, emphasis is on grades for Douglas-fir, larch, hemlock, cedar, and Sitka spruce. This phase of the program is being directed by the Douglas-fir section of the National Log Grade Project.

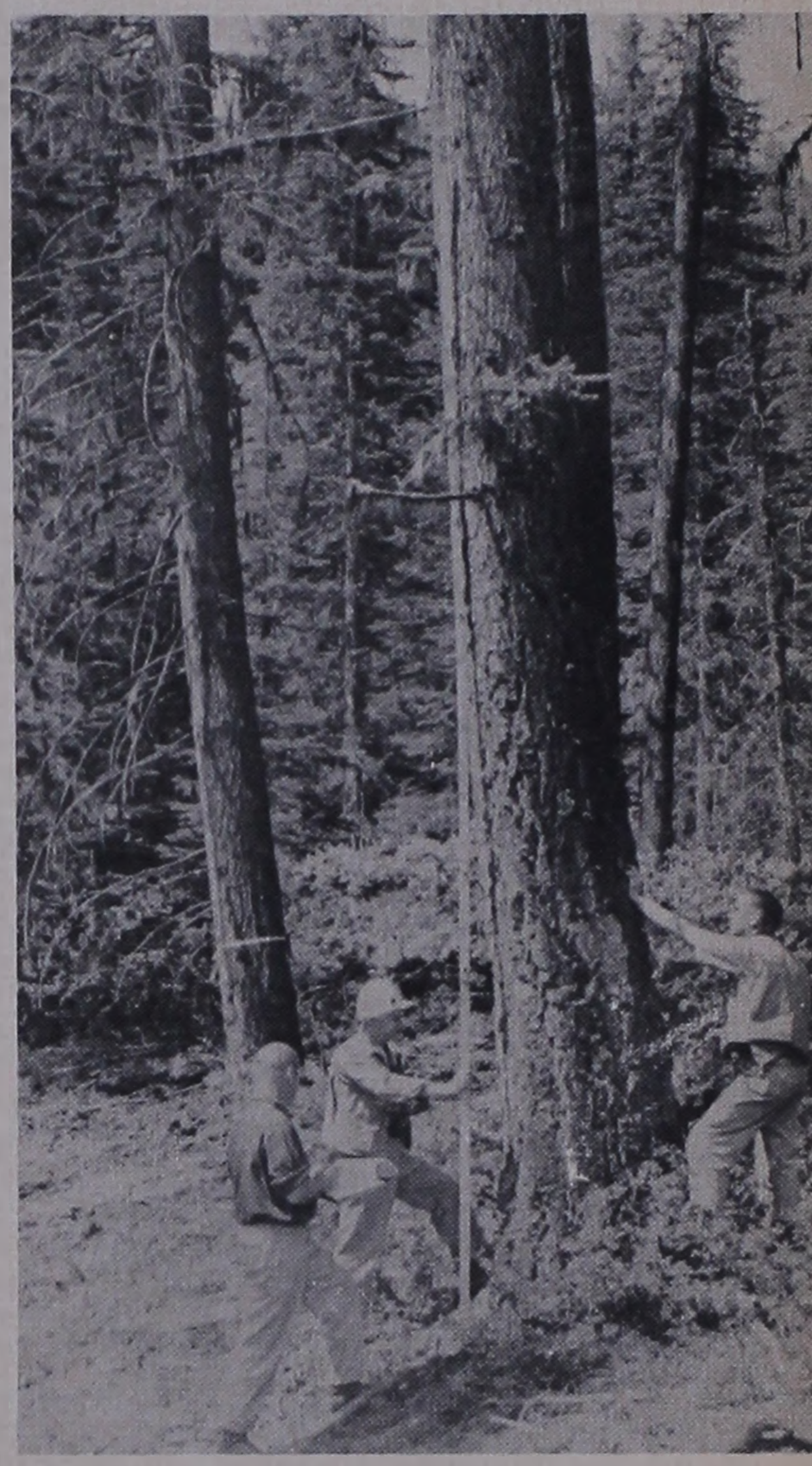
In 1961 the program was initiated in the Pacific Northwest with an interregional study of inland Douglas-fir. The primary objective of the inland Douglas-fir study is to develop standards for grading saw logs and standing trees that can be applied uniformly throughout the inland commercial range of the species.

Log yield data are being collected from representative trees in four regions: (1) northern Idaho and western Montana, (2) northeastern Oregon, (3) southern Idaho, and (4) New Mexico and Arizona. In each region about 250 sample trees will be sawn at a representative mill. Detailed information is recorded for each tree prior to falling, including visible characteristics of the crown and stem, stand conditions, and site. Surface characteristics of each log from the sample trees are carefully diagramed, and a record is made of the kind and amount of lumber produced. These data on log and tree characteristics

and environmental factors will be correlated with the lumber yield and value to develop new grading systems or to improve existing ones.

The sample trees in each region are being selected from about 10 different timber sale operations in order to get a representative distribution of tree sizes and quality. Many member mills of the Western Pine Association are cooperating by cutting, hauling, and processing the sample trees.

During 1961, sample logs from northern Idaho, western Montana, and northeastern Oregon were sawn, and the data are currently being analyzed. The remainder, from southern Idaho and Arizona, will be sawn in 1962. Work has started on a similar study of western larch.



Field crew collecting data on tree characteristics for the inland Douglas-fir log grade study.

Lumber and Veneer Recovery

Lumber and veneer recoveries are being determined on a continuing basis to provide data for equitable timber appraisal. Although the primary purpose of our current studies is to provide up-to-date appraisal data, they also yield valuable information for log grade development. As these studies progress, we are working continuously to improve field procedures and analysis techniques. Resulting grade recovery information and the methods developed to obtain recovery values should both be useful to companies segregating logs for highest value use.

During the past year, veneer recovery from western hemlock and silver fir was determined at a Washington plant. Both peeler grade and No. 1 Sawmill

logs from the Olympic Peninsula and Cascade Range were included in the study. Veneer recovery was determined for peeler blocks and for saw logs using commercial grades and on the basis of plant use.

A change in Western Pine Association grading rules for Douglas-fir and western larch dimension lumber from Nos. 1, 2, 3, and 4 grades to "name" grades identical with those of the West Coast Lumber Inspection Bureau necessitated a comparison of recovery values under the two grading systems. Consequently, nearly 250,000 board feet of Douglas-fir and larch dimension, graded under the old rules, was regraded under the new rules and differences in recovery value computed. A loss in value was observed under the new rules, resulting chiefly from the stricter limitations on shake.

The lumber recovery study, conducted at two mills in different localities of eastern Oregon, revealed that the rule changes had a considerably different effect on values at each mill. The difference was largely attributable to the greater amount of shake in the logs processed by one mill. However, when either mill was considered separately, the grade changes had an almost identical effect on the recovery values of Douglas-fir and of larch.

Lumber grade recovery from white fir (Abies concolor) was studied in southern Oregon. Five hundred and twenty logs were scaled and graded under three different systems so that the recovery data would have widest applicability to timber appraisal. The scaling and grading systems that were applied included west-side bureau grades with long-log and short-log scale and east-side associated species grades with short-log scale. Results of the study, now being analyzed, should provide informative comparisons between the grading and scaling systems as well as data for timber appraisal and log grade development.

Lumber grade recovery from inland Douglas-fir of northeastern Oregon was determined as a part of the Douglas-fir log grade project. Approximately 1,100 logs were scaled by the Western Pine Association and the Forest Service under current scaling practices. The logs were also scaled by the Forest Service under a proposed modified practice. The logs were graded by trial log grades for associated species. A supplementary sample of 327 18- and 20-foot logs was made to show comparative overrun for logs of these lengths when scaled as one log and as two logs.

TIMBER HARVESTING

The Potentials of Helicopters in Logging

In the past, the Station's interest in logging studies has centered largely around the relationship of timber harvesting to timber management and watershed management research. During the past 2 years, however, there has been a growing need to emphasize harvesting research per se. One example is the need to explore the potential of helicopters for harvesting areas that for one reason or another cannot be logged by conventional means.

In preparation for more intensive study of the possibilities of helicopter logging in the Pacific Northwest and Alaska, the Station has entered into a cooperative agreement with Oregon State University for a preliminary analysis. This initial study will compile data on helicopter and timber stand characteristics as a basis for estimating the potentials of helicopter logging. In particular, the study is designed to reveal the location, nature, and extent of stands that are difficult, if not impossible, to log by present methods and to determine for these stands the relationship of average log loads to machine capacity.

Since operating costs of helicopters considered suitable for logging may exceed $400 per hour, it is vital to determine as accurately as possible the log load per trip that could be anticipated. Many phases of this proposed logging system must be studied further to assess its true potential, but the exploratory study indicates that helicopters offer greatest potential benefit to coastal Alaska.

PRODUCT SERVICEABILITY

Effective and efficient use of wood as a structural material is complicated by the variability in its mechanical properties. Mechanical properties vary between species, between individual trees, and even within individual trees. It is not surprising, therefore, that allowable working stresses for wood products based largely on average strength penalize the stronger material in order to insure that low-strength pieces will perform adequately. As competition from other building materials increases, it is essential that wood be used more efficiently. One means of insuring this is through more precise knowledge of wood's strength properties.

Western Wood Density Survey

The Western Wood Density Survey, begun in 1960 by the Forest Service with the cooperation of industry and several public agencies, will provide much needed information on the variability in mechanical properties of all western species. In this extensive survey more than 40,000 trees in the western States will be sampled by means of increment cores, as described on page 42.

Wood density, which can be determined from these cores, fortunately provides a useful index to strength properties. Since such important characteristics as stiffness, bending strength, and compressive strength are related to wood density, the density survey will tell the range in strength properties within a species.

A contribution of $300,000 to the survey in early 1961 by the West Coast Lumbermen's Association, Western Pine Association, and Douglas Fir Plywood Association has greatly accelerated progress. With additional help from State and Federal agencies, it has been possible to complete more than half of the core sampling job. Analysis of the cores at the U.S. Forest Products Laboratory is proceeding on schedule, and the job of relating the density of a breast-high core to the average density of merchantable wood in a tree is on schedule for the nine western species most important in structural use.

To establish the relationship of core density (breast high) to the average tree density requires analysis of transverse disks taken at several heights in 100 or more trees of each species. Examination of the disks reveals the wood density of a tree at several heights which can then be combined to give the average wood density for the merchantable bole. By plotting the average wood density of all trees sampled over their core density, a mathematical relationship can be established that will represent any tree of the species with reasonable accuracy.

Collecting disks for Western Wood Density Survey. Disks taken at specified heights in the bole are used to find average density of tree.

Results of the Western Wood Density Survey will contribute in several ways to the more efficient use of wood as a structural material. For example, by revealing the range of wood density within a species, the survey will show whether or not previous strength tests have covered this range fully. If the tests do not cover the full range, survey results will indicate what type of material should be included in additional tests in order to establish realistic average strength values for a species. Furthermore, in covering a wide range of altitudes, latitudes, slopes, exposures, etc., the survey results may reveal what site factors significantly affect wood density and related properties. Finally, the survey may identify naturally occurring trees of superior properties that would be valuable in propagating the species.

Evaluating Strength Nondestructively

Since a solution to the structural grading problem is critical to the lumber and plywood industries of the Pacific Northwest, the Station is constantly exploring possible solutions with the industry and seeking to emphasize the problem to other research groups.

As important as the Wood Density Survey is in establishing average strength values for each species, there is need for even more selective strength determination. Specifically, there is need to rate the strength or stiffness of individual pieces of lumber or plywood, if these materials are to be used to greatest advantage. Authorities on structural grading have concluded that the ideal approach is to grade individual pieces for strength by some nondestructive test. There has been encouraging progress during the past year in this direction. Nondestructive testers for lumber, developed by Potlatch Forests, Inc. and the Western Pine Association, measure the important property of stiffness in dimension lumber and indirectly indicate other strength properties. Successful application of such equipment to lumber and plywood grading would give structural designers a more reliable engineering value for wood members and vastly improve their competitive position with respect to other structural materials.

Despite the encouraging progress of current work, there is need for greatly expanded effort in nondestructive testing. As one means of focusing attention in this field of research, the Station arranged for representatives of the U.S. Forest Products Laboratory; the Canadian Forest Products Laboratory at Vancouver; the forest products laboratories of California, Oregon, and Washington; three major lumber producers; two lumber associations; and two Forest Service experiment stations to meet for 2 days last summer to discuss nondestructive testing. The review of present knowledge, current progress and problems, and research approaches to those problems was encouraging to all concerned.

New Performance Program

The ultimate test of any product is how it performs in service. A history of satisfactory service generally need not be very long to be accepted as proof of performance; however, it must be authoritative and impartial, which normally implies systematic, perceptive observation of a product's behavior over a period of several years. Such research is complicated and time consuming, but significant and convincing performance data can be developed with reasonable economy by using modern techniques of scientific measurement and analysis.

In discussing problems of product performance and how to predict it with interested research groups, producers, secondary processors, and users, the Forest Utilization Research staff has found an urgent need and desire for better organized service testing. To help satisfy this need, we have developed during the past year a comprehensive plan for research covering the performance of products under environments typical of the Pacific Northwest. This program was recently approved and is expected to become a long-range adjunct to the work of the Station. It will supplement the overall forest products utilization research programs of the Forest Service and particularly the studies of the U.S. Forest Products Laboratory. It will also be coordinated to the greatest degree possible with performance research of industry and public agencies in the region.

The program's three fundamental objectives are to define more precisely how wood performs under actual service conditions, to determine the significant factors that influence performance, and to seek economical means of improving product serviceability. Initial emphasis will be on wood uses and types of wood structures already under study by the division. The experimental techniques currently employed will be strengthened and standardized. Existing projects will be reorganized for greater economy and productivity. Present studies--including performance of house framing lumber as related to moisture content, glued laminated members in bridges and buildings, and various surface coatings on exterior wood surfaces--will be expanded to include additional structures and types of products. New projects will be undertaken as manpower becomes available.

Where possible, Forest Service timber structures will be used for performance studies. The variety of these structures, their geographic spread throughout the region, and the convenience of internal administration make them particularly attractive for the planned program.

Timber Bridges

In August of this year, for the first time since 1959, the Forest Utilization staff made an extensive inspection of timber bridges in the region, in cooperation with the Division of Engineering, Region 6. Bridges with glued laminated wood members were of principal interest. Some of our general conclusions drawn from the inspection of 17 bridges geographically distributed in Oregon were (1) that heavy surface residues resulting from oils and tars used in preservative treating give good protection against delamination and seasoning checks; (2) that timber bridges in the more arid climates require less maintenance than those in the humid areas; (3) that design features--wide deck overhangs, for instance--strongly influence performance of structural parts; and (4) that when treated laminated members are fully exposed to the weather, as those in bowstring or arch-truss type bridges, a flexible surface coating would greatly reduce weather damage and prolong service life.

Exposure Site

During the year, the Station arranged for the installation of a new product test site for the U.S. Forest Products Laboratory near Olympia, Wash. This new natural environment exposure site, located on a 10-acre tract of land leased from the State of Washington and adjacent to the Webster State Forest Nursery, is one of four in a national network. These sites will simultaneously expose specimens of a variety of wood products to the four climatic extremes found near Gulfport, Miss.; Madison, Wis.; Fresno, Calif.; and Olympia, Wash., respectively. The first series of specimens, matched with those sent to the other three testing sites, were installed at Olympia late in 1961. The Olympia site has been prepared and will be maintained by personnel of the State Department of Natural Resources under cooperative agreement with the Forest Service.

Douglas-fir Utility Poles

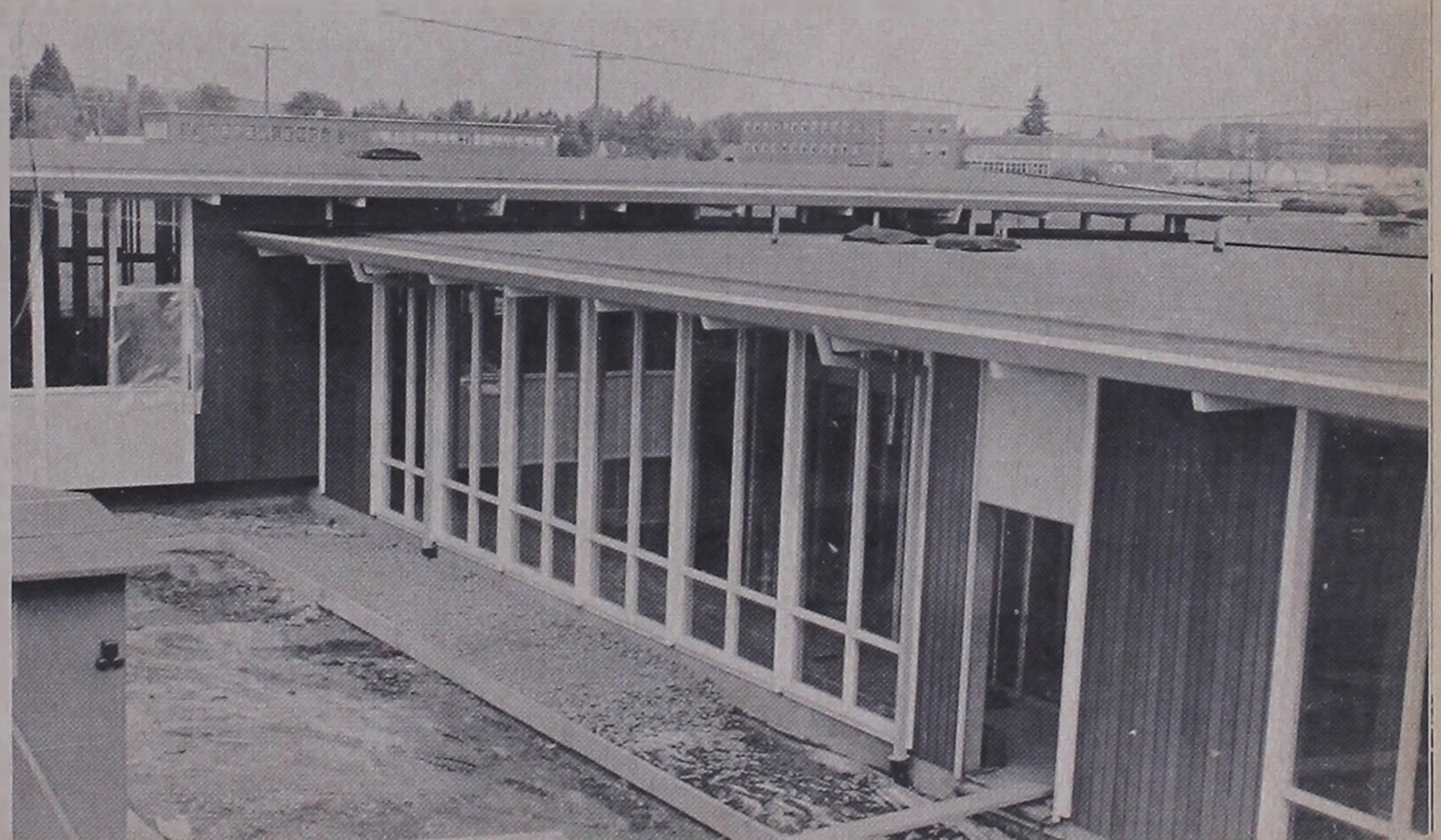
Douglas-fir poles are uniquely important to the utilities industry of the United States, since only Douglas-fir offers the combination of size, strength, and form needed to carry heavy transmission lines. Observations of installations since World War II have demonstrated that conventional preservative treatment may not provide the expected service life. The principal cause of some premature failures is the exposure of untreated wood when season checks develop in the pole after treatment.

We are now participating in the efforts of the research committee of the Western Wood Preserving Operators Association to solve this problem. A number of approaches are being tested or considered, including preseasoning, improved Boultonizing, various methods of incising or boring to improve penetration, and entirely new preservation processes. The Station will concentrate on a study of the effect of incising on the checking pattern in poles after treatment and, in addition, will provide liaison with the U.S. Forest Products Laboratory.

Forest Service Wood Use

The Forest Service itself has many opportunities to demonstrate good wood utilization in construction. A substantial number of new structures are required annually to meet the needs of the national forests and the research establishments. These and the many existing structures operated by the Forest Service are mostly of wood construction. They are quite varied as to type and probably represent the full range of normal wood usage.

In its new Forest Insect and Disease Laboratories at Corvallis, Oreg., the Station has specified many new and advanced wood products, including laminated Douglas-fir columns and beams, 3-ply glued lumber roof deck, plywood-paper honeycomb curtain wall panels, integral subflooring and finish flooring, vertical redcedar channel siding, and western hardwood plywood for interior paneling. All exterior and foundation woodwork is preservative treated by methods specifically suited to the hazard and use requirements.



The Station and Forest Administration have found it very rewarding during the past year to work together on design and maintenance of wood structures. By applying the results of the latest research to construction problems, initial costs and normal upkeep can be reduced. There is also an opportunity to introduce new and improved types of products that have not been widely accepted and marketed.

At the Olympia laboratory, two types of polyurethane varnish were applied as clear coatings on laminated Douglas-fir roof beams. These beams have varying orientations to the elements and differing degrees of protection from other parts of the structure. Polyurethanes are one of the more promising developments in the continuing search for an adequate clear coating for exterior wood products.

Wood products and structures given joint consideration include ranger station residences and service buildings, bridges, lookout towers and houses, public information signs, laboratory buildings, and recreation and exhibition structures. It is expected that structures thus developed will be integrated into the Station's program of wood performance studies, described more fully above.

Pulping Western Woods

The need to improve the suitability of Douglas-fir for a greater variety of paper and board products continues to be a major utilization problem of the Pacific Northwest.

Although the equivalent of more than 2 million cords of Douglas-fir, chiefly in the form of chips from mill residues, are used annually by this region's pulp and board industry, the potential supply of Douglas-fir chips still exceeds demand. Improvement in the versatility of Douglas-fir pulps through modified pulping processes, pretreatment of chips, or blending with other species would greatly benefit the region's forest-based economy.

Experimental application of multistage pulping processes to Douglas-fir will be accelerated at the Forest Products Laboratory during the coming year. Research on the composition of extractives in Douglas-fir and their relationship to pulping characteristics of the wood also will be undertaken.

PLANS FOR 1962

- Continue the national Douglas-fir log grade project with studies on inland Douglas-fir and western larch to develop log and tree grades for the two species. Comprehensive lumber recovery studies will be conducted on Douglas-fir in Regions 3 and 4 and on larch in Region 6.

- Continue the closely related Region 6 appraisal-base studies, with studies of veneer recovery from Douglas-fir saw logs and of lumber recoveries from western larch and inland Douglas-fir. The need for current data for accurate timber evaluation of an increasing number of species requires

heavy emphasis on this program. Refinement of techniques used in these studies will continue.

- Cooperate with industry, the Forest Products Laboratory, and other research agencies in a twofold effort to refine the grading of lumber and plywood for structural use by (a) working to speed the Western Wood Density Survey and (b) facilitating research on an adoption of nondestructive methods of stress rating lumber and plywood.

- Expand the limited studies on the serviceability of wood products by implementing the outlined research program, "Evaluating and Improving the Performance of Wood Products in the Pacific Northwest." This program will be coordinated with the environmental research program of the Forest Products Laboratory, including exposure tests at the new Olympia site, and with the construction and maintenance program of Region 6.

- Continue preliminary research on the feasibility of helicopter logging in the Pacific Northwest and Alaska by extending cooperative research in this field with Oregon State University. Assist in establishing a forest engineering research program in this region.

- Improve liaison between the Forest Products Laboratory and industry or other agencies in the Pacific Northwest by (a) arranging visits of the Laboratory's staff to the region, (b) encouraging technical group meetings--such as sawmill clinics--and, (c) discussing individual research problems with technical men and industry management.

- Participate in the national analysis of timber quality needs as related to end uses.

- Participate in the research efforts of the western wood preserving industry to extend the service life of utility poles of Douglas-fir and other thin sapwood species.

Forest Insect Research

Breaking of ground for the Corvallis laboratory on May 8, 1961, was a long-awaited milestone. Completion of the laboratory in the spring of 1962 will open many opportunities for basic research not previously available. Personnel were recruited for initial staffing in the three major lines of insect research to be undertaken at the laboratory: (1) diseases, (2) biological control, and (3) physiology, nutrition, and behavior.

On July 1, 1961, insect surveys were officially transferred to Forest Pest Control in the Division of Timber Management in the regional office. However, the Station continues to make special biological evaluations of certain insect outbreaks.

In a cooperative crash program of research, we helped develop a fumigation method urgently needed for eradication and quarantine efforts to prevent spread of the European pine shoot moth to natural stands of ponderosa pine.

Our research program progressed on a broad front. Especially notable accomplishments were: (1) demonstrated effectiveness of one imported predator of the balsam woolly aphid, (2) development of an improved bio-assay method for gaging the insecticidal activity of commercial preparations of Bacillus thuringiensis, and (3) findings concerning a presumed granulosis virus of the spruce budworm.

EUROPEAN PINE SHOOT MOTH

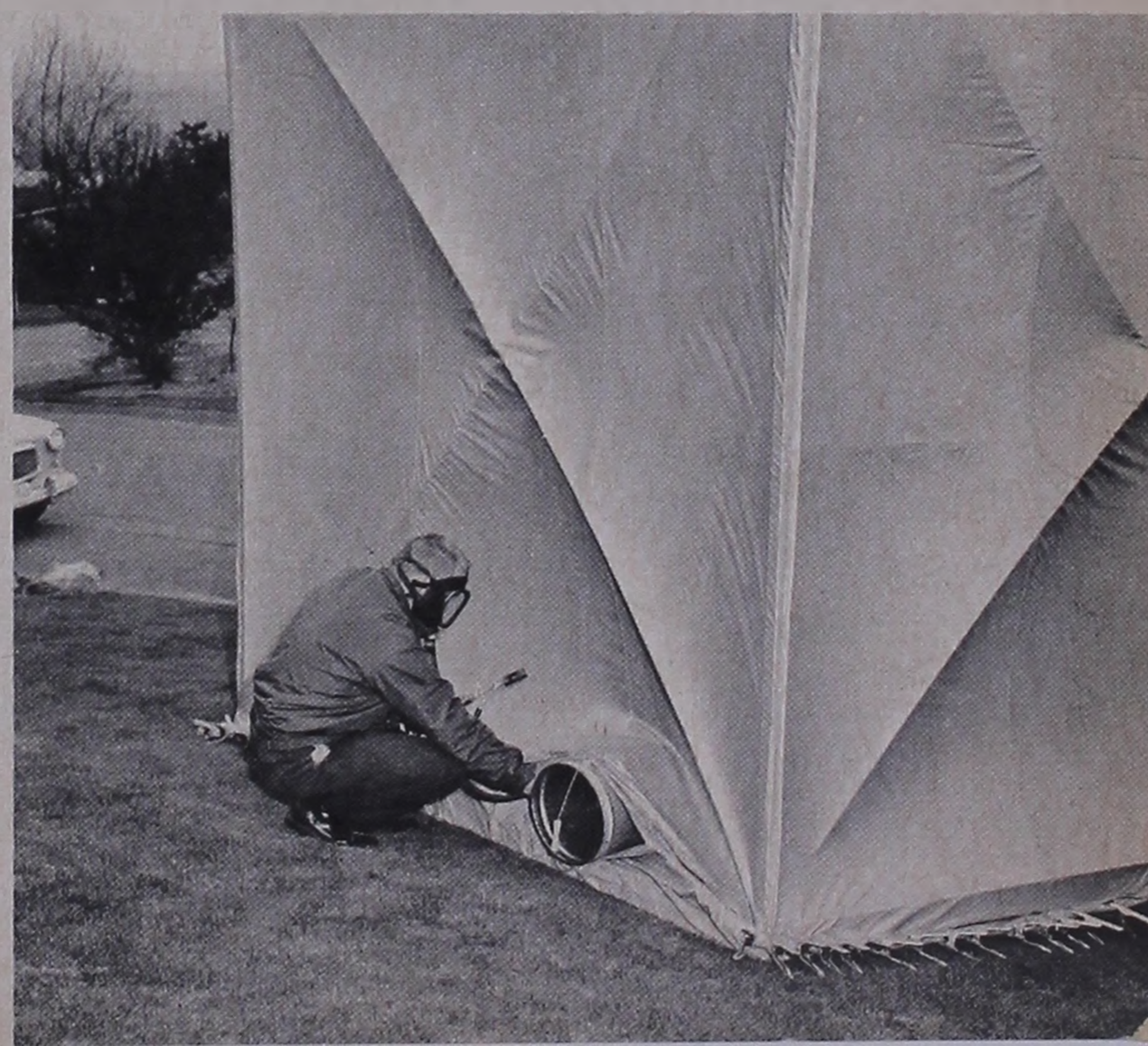
Cooperative studies, begun in 1960, to develop an effective method of fumigating with methyl bromide against the shoot moth were continued. The objective of these studies is to develop a method that can be used for eradication and quarantine purposes to keep the shoot moth from spreading to natural stands of ponderosa pine. We completed a series of tests on individual ornamental pines growing in residential areas in Seattle, Wash., and a pilot test in a commercial ornamental tree nursery near Bothell, Wash. A study was commenced in December at a State of Washington forest tree nursery to determine the tolerance of planting stock to methyl bromide.

We found that time lapse and temperature during treatment were much more important than gas concentration in attaining 100-percent control of the shoot moth without excessive damage to the pine. In successful treatments, the margin between those causing no tree damage and those causing damage was quite narrow. With optimum combinations of time and temperature, 100-percent control could be obtained nearly every time without causing tree damage.

However, in each major seasonal test, one of the trees given optimum or slightly excessive treatments was found to have a surviving shoot moth. In early fall, lodgepole pine was extremely sensitive to damage by methyl bromide. In late fall, this species showed tolerance comparable with that of Scotch, mugho, Austrian, and Japanese black pines.

Fumigation of the ornamental tree nursery was based on optimum time and temperature combinations developed during the single-tree tests. Some variations in the methods of application were made to test different planting situations. It is too soon to determine precisely how much tree damage has occurred. However, in two treatment groups larval mortality was not complete. We must still determine whether modifications in the technique for applying the gas or the treatment itself was at fault.

Lifting 10- by 10-foot chamber into place for methyl bromide fumigation test.



Safety checking for residual methyl bromide gas in 10- by 10-foot chamber after fumigation of ornamental pine.

SPRUCE BUDWORM

In southern Washington, a relatively small outbreak was intensively studied and evaluated because of its biological similarity to the extensive outbreaks of the past in northeastern Oregon. The studies showed that a definite upward trend of the budworm population occurred in 1961, with the increase being greater on white fir than Douglas-fir. Studies of parasites showed that (1) total parasitism was essentially the same in 1961 as in 1960, (2) parasites attacking small larvae were less effective on white fir than Douglas-fir, and (3) the major parasites attacking full-grown larvae showed no change in effectiveness. Increased tree damage, combined with a predicted budworm increase next year, prompted the Northwest Forest Pest Action Council to recommend spraying of the area in 1962.

Good progress was made on a cooperative study with Oregon State University to develop techniques for mass-rearing the budworm in the laboratory. Greater efficiency in the rearing process and increased larval survival were obtained by (1) using disposable containers, (2) substituting agar-coated Douglas-fir needles for frozen buds as food, and (3) rearing the small larvae in complete darkness. Attempts to shorten or eliminate diapause in the second larval instar by temperature, humidity, and light manipulations were continued but as yet these attempts are in the data-collecting stage.

PINE NEEDLE MINER

We continued an exploratory study of an unidentified pine needle miner which may become an important pest of ponderosa pine in southern Oregon. Data were obtained on the life cycle of the miner and on the effects of natural control factors, which if substantiated in subsequent years, will provide a basis for determining population trends. This information, combined with damage evaluations, can provide a basis for forecasting control needs.

CONE AND SEED INSECTS

Our investigations of cone and seed insects of Douglas-fir in 1961 pointed up practical problems that will be encountered by foresters attempting control of these pests. The main problems are concerned with weather. Designed spray studies on one area near Shelton, Wash., had to be abandoned because rain and other weather conditions prevented application of the spray during the period when the target insect, the Douglas-fir cone midge, was susceptible to treatment. A small substitute study, conducted in an area of later phenological development, showed that neither Sevin nor benzene hexachloride was significantly effective in controlling the Douglas-fir cone midge. Again, however, spray application could not be applied at the optimum time because of inclement weather, and a fair test may not have been accomplished.

Biological studies of cone moths of the Laspeyresia-Hedulia group in ponderosa pine showed that most of the larvae which overwintered in the axes

of 1960 cones did not emerge in 1961. This optional habit of holding over in the larval stage for a second year is well known. The advantage to the insect of doing this in 1961 was apparent in view of the fact that there were practically no second-year cones for it to attack. Observations indicate that second-year cones will be abundant in the spring of 1962, when the hibernating cone moths from 1960 cones are expected to emerge in force.

BALSAM WOOLLY APHID

Our program, conducted cooperatively with the Canadian Department of Agriculture, Commonwealth Institute of Biological Control, and Agricultural Research Service, to control the balsam woolly aphid by introducing natural enemies from foreign lands was continued for the fifth consecutive year. Fewer insect predators were introduced in 1961 and more attention paid to those colonized previously. Of five species imported, all from India and Pakistan, only one--a green lacewing--was actually liberated in the field. The others were tested in the laboratory.

Of the 18 species colonized before 1961, 4 have become established--a small beetle and 3 tiny flies, all from western Europe. An additional species, a ladybird beetle from Germany, is believed established, but more checking is needed for confirmation.

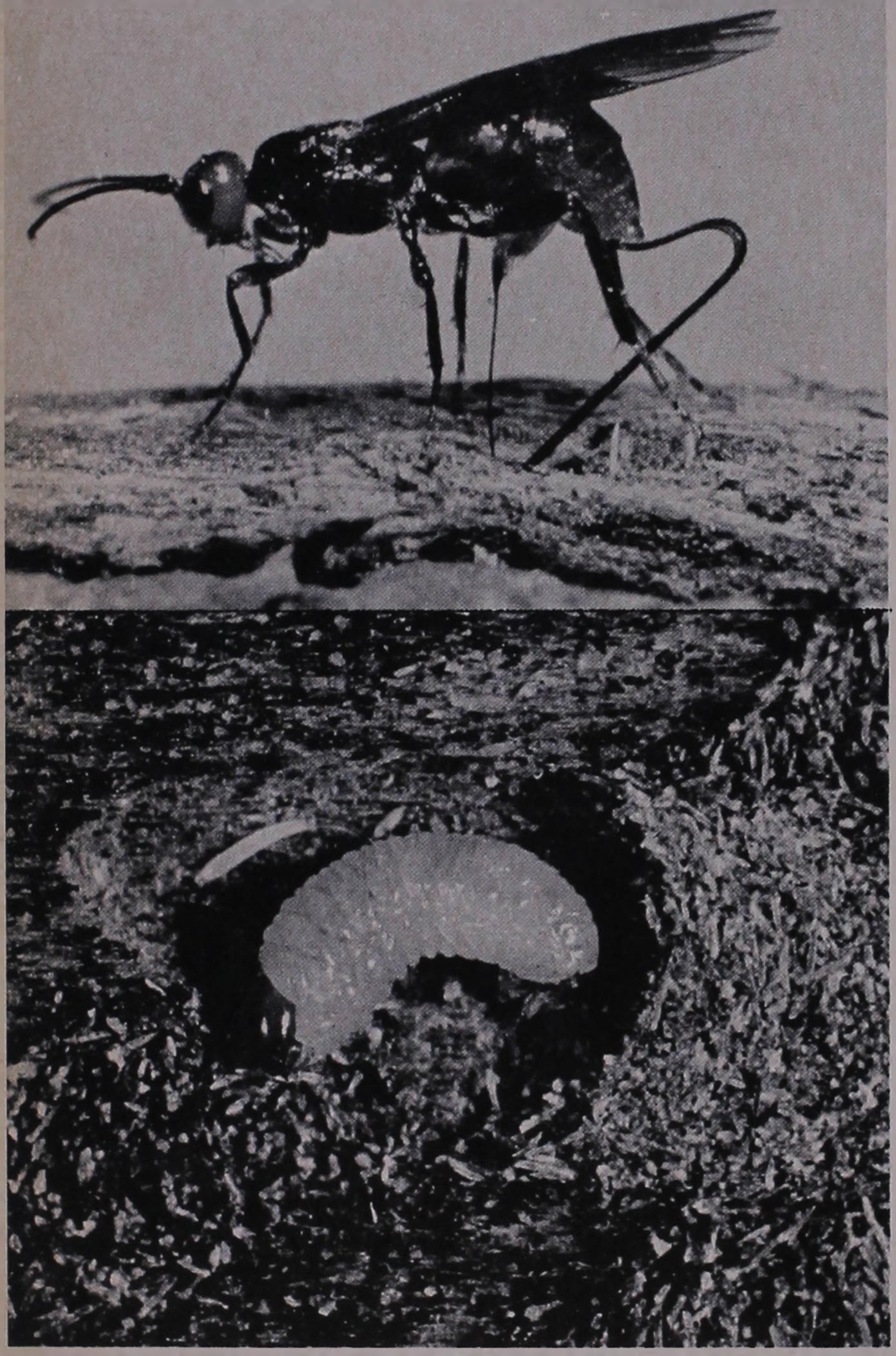
Success of the three established flies is encouraging, but the most effective predator appears to be the beetle, Laricobius erichsonii. Populations of it are large on almost all liberation areas, and dispersal is good. On one area, the diameter of spread measures one-half mile. Most important though, is the beetle's ability to reduce aphid populations. Studies at Willamette Pass, Oreg., revealed that this predator had become so abundant that it was eating more aphids than were being produced--a step towards true control.

We also investigated effects of the balsam woolly aphid on its true fir hosts. The latest study, a cooperative venture with Weyerhaeuser Co., investigated the effects of aphid infestation on growth rate of Pacific silver, subalpine, and grand firs. In general, stem-infested Pacific silver and subalpine firs die soon after initial attack, often within 2 to 4 years. Grand fir, on the other hand, will withstand heavy infestations 12 years or longer but may suffer serious growth loss, particularly in height.

BIOLOGICAL CONTROL

Over the years, we have studied many parasites and predators of native forest insects. Some efforts have been made to increase their effectiveness, but so far without much success. Foreign insect parasites and predators have been colonized, especially predators of the balsam woolly aphid. These activities were given project status in 1961 with the employment of a full-time specialist, who will be located at the Corvallis laboratory and assigned basic studies.

Studies made cooperatively with Oregon State University have led to a method for mass-rearing Coeloides brunneri Vier., an abundant insect parasite of the Douglas-fir beetle. However, practical application of this technique is restricted at present because effectiveness of the parasite is limited by the thick bark on old-growth trees. Presumably it will be more effective in the intensively managed stands of the future in which the bark protecting the beetles will average much thinner.



Female Coeloides brunneri *laying egg through Douglas-fir bark.*

Egg of Coeloides brunneri *on Douglas-fir beetle larva in its cell beneath the bark.*

DISEASES OF INSECTS

Studies of diseases of insects have continued in temporary quarters in the Department of Entomology of Oregon State University. Considerable time was spent on laboratory and program planning. An analysis was made of research needs pertaining to diseases of bark beetles. Cultures of a variety of insect pathogens were maintained. Our disease studies were along three main lines:

1. Bio-assay of Bacillus thuringiensis material. Commercial production of Bacillus thuringiensis as a biological insecticide developed recently. It was soon found that the commercial products varied markedly in insecticidal activity, even between different lots produced by the same company. These variations in effectiveness continue to give trouble. They cannot be correlated with spore or para spore counts. Bio-assay methods using various leaf feeding Lepidoptera have not been completely satisfactory.

   By an extensive investigation, we developed a bio-assay method, using larvae of the greater wax moth, Galleria mellonella (Linn.), an insect that can be mass-produced easily and economically throughout the year. Although there are some variations in results, this method is more consistent than present methods using leaf-feeding insects.

   The new method consists of adding two millileters of suspension of test material to a disc of filter paper in a standard petri dish. The suspension is standardized either to spore count or to weight. For each test of a preparation of B. thuringiensis, 20 nearly mature wax moth larvae are added to each of 20 dishes. A standard material is used in each test as a positive control and 20 untreated dishes are used as a negative control. Since the insects do not require food during the test, the effort in conducting this assay consists of introducing the larvae into the prepared petri dishes and determining the results 7 days later.

2. Virus disease of the spruce budworm. In 1960, a disease was found to be killing considerable numbers of the green form of the spruce budworm in south-central Oregon. Laboratory examination indicated that a granulosis virus caused the disease. This was considered to be a significant find because little evidence of appreciable kill of the spruce budworm by disease had previously been observed.

   Studies of the disease were continued in 1961, both in the field and in the laboratory. The disease was rarely observed in the field. However, among several thousand field-collected larvae brought to the laboratory for study, an apparent granulosis was common. Many larvae died within a week of collection, indicating that the virus was present in a latent state in the field population. It is surmised that

stress conditions subsequent to collection--low temperature, high humidity, and crowding--may have activated a latent virus.

Examination by the light microscope indicated that nearly all the field-collected larvae contained granules which were assumed to contain virus rods. However, approximately half of the unparasitized larvae did not die, but produced apparently normal and fertile adults. Some larvae recovered even after showing what were considered to be advanced symptoms of the disease. Some reservation is made in diagnosing the apparent disease as a granulosis because verification by electron microscope examination was not possible. In addition, the pathology was not entirely typical of the granuloses in general.

Laboratory tests, in which budworm larvae were fed foliage dipped in dilute suspensions prepared from the bodies of dead larvae, apparently confirm that the disease is contagious. The period of infection averaged 7 days for the green form of the budworm and 21 days for the "standard" form.

3. Entomogenous fungi. Cultures of various strains of entomogenous fungi are being maintained for experimentation with forest insects. Certain of these fungi, when preserved on artificial media for many years, lose much of their original vigor and virulence. By passing these devitalized fungi 10 to 15 successive times through larvae of the greater wax moth, we have renewed their vigor.

Wax moth larvae on which strains of Beauveria are being revitalized.

PLANS FOR 1962

- Install and equip for projected program of insect research in new laboratory on campus of Oregon State University.

- Conduct a comprehensive program of research on fundamental nature of insect diseases and on possibilities of using disease organisms to control insects.

- Develop and undertake a program of research in insect physiology.

- Continue and expand studies of biological control by insect parasites and predators.

- Continue and report upon tests of methyl bromide fumigation against European pine shoot moth.

- Continue efforts to develop methods for mass-rearing representative forest insects under controlled conditions for a variety of study purposes.

- Continue and expand long-term studies of the spruce budworm, bark beetles, chermes, insects attacking tree seeds and regeneration, and others.

Biometrics Research

An electronic computer program may merely be a useful tool for research, or, if there is application beyond an immediate problem, it could be considered a research result in its own right. During 1961, we wrote reports for three computer programs which have been developed in the Station and which may be useful to others. These reports cover technical details of the data processing procedure. They do not have the status of formal publications, but have been reproduced for limited distribution. Each report is described briefly below:

1. Specifications for processing data from national forest timber cruises, program 650-15. Statistical Techniques Report No. 1-61.

   Research for this program was completed in 1960, and general features of the program were covered in the 1960 Annual Report.

2. Percentages by lumber grades for lumber recovery studies; electronic computer program 650-21. Statistical Techniques Report No. 3-61.

   Program 650-21 is one in a series of computer programs used for processing data from lumber recovery studies. It takes surfaced-dry lumber volumes by lumber grades for individual logs and develops percentages by lumber grades for all logs in each log grade-log diameter class.

3. Lumber tally volume by lumber items by logs for lumber recovery studies; electronic computer program 650-16. Statistical Techniques Report No. 4-61.

   Program 650-16 converts dimensions for individual boards, as measured on the green chain or in the surfaced-dry condition, into board feet, and presents lumber tally volumes by lumber grades (or by width thickness classes within lumber grades) for individual logs as output information.

1961 Publications by staff members and cooperators

FOREST ECONOMICS

Choate, Grover A.
Estimating Douglas-fir site quality from aerial photos. Pac. NW. Forest & Range Expt. Sta. Res. Paper 45, 26 pp., illus.

(Develops an equation for predicting site index from a number of physiographic features visible on aerial photographs or topographic maps. Because of limited precision, the method is primarily useful in remote country where field costs are high.)

Fedkiw, John.
Death stalks in fir forests. Advance roading captures mortality and increases overall utilization. West. Conserv. Jour. 18(4): 10-13, 42-44, illus.

(A popular version with photographic illustrations of the opportunities for increased utilization of the gross growth and inventory of the forests of the Douglas-fir subregion through advance roading and expanded partial harvest operations.)

Advance roading for increased utilization in the Douglas-fir region--Oregon and Washington. 51st West. Forestry Conf. Proc. 1960: 64-68.

(Evaluates the opportunity for increasing the timber supply in the Douglas-fir subregion through capture of annual and catastrophic mortality, salvage of dead timber, prelogging and sanitation cuts in old growth, and thinnings in young growth. Identifies the opportunity as an economic problem in capital management and market development. Defines advance roading of currently undeveloped areas as the big timber management task of the future in the Douglas-fir subregion.)

Gedney, Donald R.
Number of trees by diameter class in the forests of eastern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 216, 4 pp.

(Presents for species or species groups the number of trees by diameter classes in public and private ownership in eastern Oregon.)

MacLean, Colin D., and Pope, Robert B.
Bias in the estimation of stand height from aerial photos. Forestry Chron. 37: 160-161, illus.

(Analysis of stand height measurements on aerial photos showed that all interpreters underestimated short stands and overestimated tall stands, even though the size and pattern of their measurement errors differed.)

McMahon, R. O.
The economic significance of mortality in old-growth Douglas-fir management. Pac. NW. Forest & Range Expt. Sta. Res. Paper 37, 21 pp., illus.

(Mortality can be recovered economically under given conditions by establishing roads well in advance of final harvest. Economic considerations and criteria determining priority in choice of stands are analyzed. A high priority for intensifying operations to capture mortality losses is implied by the substantial annual volume and value of mortality in old-growth Douglas-fir.)

Newport, Carl A.
Dead timber salvageable. Pulp & Paper 35(16): 50, 52, illus.

(A graphic and tabular presentation of raw material sources for woodpulp in the Pacific Northwest, by counties and species.)

Economics of forest pest control. In Forest pest conditions in western North America, 1960. West. Forestry & Conserv. Assoc., pp. 10-11.

(Explains certain basic aspects of pest control economics, and illustrates these with an example of economic analysis applied to dwarfmistletoe control in ponderosa pine.)

Pope, Robert B.
Aerial photo volume tables for Douglas-fir in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta. Res. Note 214, 8 pp.

(Presents aerial photo stand volume tables in both board feet and cubic feet, with a brief description of how they were made and how to use them.)

FOREST MANAGEMENT

Barrett, James W.
Response of 55-year-old lodgepole pine to thinning. Pac. NW. Forest & Range Expt. Sta. Res. Note 206, 8 pp., illus.

(Presents results of a 22-year growth record from a thinning experiment in central Oregon. Stand responded exceptionally well to thinning even at this advanced age.)

Berntsen, Carl M.
Growth and development of red alder compared with conifers in 30-year-old stands. Pac. NW. Forest & Range Expt. Sta. Res. Paper 38, 20 pp., illus.

(Rapid initial growth of intolerant red alder was soon equaled and surpassed by the slow-starting and tolerant conifers. By age 29 years, a pure conifer stand about equaled the volume of 32-year-old unthinned pure alder and surpassed the yield of thinned pure alder and unthinned alder-conifer stands.)

Pruning and epicormic branching in red alder. Jour. Forestry 59: 675-676, illus.

(Gains in wood quality due to pruning were frequently offset by development of epicormic branches.)

Dahms, Walter G.
Chemical control of brush in ponderosa pine forests of central Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Paper 39, 17 pp., illus.
(Presents most promising methods for chemical control of manzanita, snowbrush, and chinkapin and discusses effect of various chemicals on ponderosa pine.)

Franklin, Jerry F.
A guide to seedling identification for 25 conifers of the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta., 65 pp., illus.
(Contains descriptions and photographs of young conifer seedlings. A key, based on diagnostic characteristics such as number of cotyledons and arrangement of foliage, is included.)

Gratkowski, H.
Brush problems in southwestern Oregon. Pac. NW. Forest & Range Expt. Sta., 53 pp., illus.
(An analysis of brush problems on forest land in southwestern Oregon, and a suggested research program for brush control and brushfield reclamation studies in that area.)

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Brush seedlings after controlled burning of brushlands in southwestern Oregon. Jour. Forestry 59: 885-888, illus.
(Burning chemically killed brush stimulated germination of brush seeds or created conditions favorable for germination. One year after burning, burned areas contained an average of 10,000 ceanothus and manzanita seedlings per acre. Few seedlings were present under unburned brush.)

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Toxicity of herbicides on three northwestern conifers. Pac. NW. Forest & Range Expt. Sta. Res. Paper 42, 24 pp., illus.
(Shows pictorially the effect of 2,4-D and 2,4,5-T in three different carriers on Douglas-fir, ponderosa pine, and sugar pine. Sprays were applied during the growing season and during the fall dormant season, after height growth had ceased.)

Gratkowski, H. J.
Use of herbicides on forest lands in eastern and southwestern Oregon. In Herbicides and their use in forestry. Oreg. State Univ. School of Forestry, pp. 65-81.
(Discusses some principles of brush control for brushfield reclamation and release of conifers from overstory brush. Outlines some of the most effective treatments developed to date for use on forest lands in eastern and southwestern Oregon.)

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Use of herbicides on forest lands in southwestern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 217, 18 pp.
(Discusses some principles of brush control for brushfield reclamation and release of conifers from overstory brush. Outlines some of the most effective treatments developed to date for use on forest lands in southwestern Oregon.)

King, James P.
Growth and mortality in the Wind River Natural Area. Jour. Forestry 59: 768-770, illus.

(Twelve years of observation in a 350-year-old stand of Douglas-fir show that while the stand is still adding considerable increment, most of the growth is being offset by mortality.)

Krygier, James T., and Ruth, Robert H.
Effect of herbicides on salmonberry and on Sitka spruce and western hemlock seedlings. Weeds 9: 416-422, illus.

(Screening trials in the Oregon coastal zone indicated that several herbicide formulations applied as foliage sprays show promise for control of salmonberry. Some formulations showed good selectivity, being effective on salmonberry yet not seriously damaging to intermingled Sitka spruce and western hemlock seedlings.)

Mowat, Edwin L.
Effect of a transpiration retardant on survival of planted ponderosa pine. Pac. NW. Forest & Range Expt. Sta. Res. Note 203, 4 pp.

(A transpiration retardant, SV Ceremul C, failed to increase survival of planted ponderosa pine in 2 years of field trials in central Oregon.)

Growth after partial cutting of ponderosa pine on permanent sample plots in eastern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Paper 44, 23 pp., illus.

(Structure and distribution of original and reserve stand have more effect upon growth and mortality than small variations in selective cutting methods. Data useful in management planning and suggested guides to future cutting practice are presented.)

Supplement to "Growth after partial cutting of ponderosa pine on permanent sample plots in eastern Oregon." Pac. NW. Forest & Range Expt. Sta. Res. Paper 44 (Supplement), 28 pp., illus.

(Study areas, methods of cutting, and statistical results are described for each of the seven sets of permanent plots. This supplement gives more detail on specific areas and a broader background of experimental data and discussion than the condensed results and conclusions in Research Paper 44.)

Reukema, Donald L.
Crown development and its effect on stem growth of six Douglas-firs. Jour. Forestry 59: 370-371, illus.

(Discusses the variability within and between trees of factors such as crown length, number and size of branches, branch longevity, and rates of branch radial growth, and the relationship of these factors to stem growth.)

Response of individual Douglas-fir trees to release. Pac. NW. Forest & Range Expt. Sta. Res. Note 208, 4 pp., illus.

(Remeasurement seven growing seasons after controlled release in a 41-year-old, site IV stand showed that response of dominants was stronger and sustained longer than that of codominants or intermediates.)

Reukema, Donald L.
Seed production of Douglas-fir increased by thinning. Pac. NW. Forest & Range Expt. Sta. Res. Note 210, 5 pp., illus.
(Seed trap catches showed that in the good seed year of 1959 thinned stands produced twice as much seed as unthinned stands. In the preceding poor seed years, thinning had not increased production.)

Tarrant, Robert F.
Stand development and soil fertility in a Douglas-fir—red alder plantation. Forest Sci. 7: 238-246, illus.
(Interplanting red alder with Douglas-fir resulted after 27 years in increased soil nitrogen and accelerated height and diameter growth of dominant Douglas-firs.)

Trappe, James M.
Some probable mycorrhizal associations in the Pacific Northwest. III. Northwest Sci. 35: 91-94.
(An additional listing of specific fungi observed to form mycorrhizae with a number of Pacific Northwest tree species.)

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Strong hydrogen peroxide for sterilizing coats of tree seed and stimulating germination. Jour. Forestry 59: 828-829.
(A 35-percent solution of hydrogen peroxide was found to effectively and conveniently sterilize seedcoats of several conifers without damage to the embryo. Seeds thus treated germinated much faster than untreated seeds.)

Worthington, Norman P.
Cost of thinning 50-year-old Douglas-fir for pulpwood at Voight Creek Experimental Forest. Pac. NW. Forest & Range Expt. Sta. Res. Note 215, 4 pp.
(Pulpwood production costs were found to be influenced by average skidding distance and diameter of average tree cut. Volume cut per acre had negligible effect.)

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Some observations on yield and early thinning in a Douglas-fir plantation. Jour. Forestry 59: 331-334, illus.
(Records of a 31-year-old plantation in northwestern Washington showed that yields were markedly higher in plantations than in natural stands, due to wider and more exact spacing.)

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Tree damage resulting from thinning in young-growth Douglas-fir and western hemlock. Pac. NW. Forest & Range Expt. Sta. Res. Note 202, 7 pp.
(Thinning trials on merchantable-size trees in western Washington indicate that losses from thinning injuries were negligible. Western hemlock was more susceptible to injury than Douglas-fir.)

Worthington, Norman P., and Staebler, George R.
Commercial thinning of Douglas-fir in the Pacific Northwest. U.S. Dept. Agr. Tech. Bul. 1230, 124 pp., illus.

(A summary of research and experimentation in the theory and practicality of commercial thinning in the Douglas-fir type indicates that thinning not only substantially increases production but, near favorable markets, will return an immediate profit.)

_____ and Staebler, George R.
Theory and practice of commercial thinning in Douglas-fir. Jour. Forestry 59: 591-593.

(A condensation of U.S. Dept. Agr. Tech. Bul. 1230 on the theory and practice of commercial thinning of Douglas-fir in the Pacific Northwest.)

FOREST PROTECTION

Disease

Childs, T. W.
Delayed killing of young-growth Douglas-fir by sudden cold. Jour. Forestry 59: 452-453, illus.

(Describes some of the delayed effects of the 1955 "deep freeze.")

Harvey, George M.
Effects of refrigeration and shipping on sugar pine field survival. Tree Planters' Notes 45: 17.

(Freshly dug sugar pine seedlings survive better than refrigerated seedlings; short transit periods (2 weeks or less) do not affect survival.)

Fire

Bruce, David.
Alginated water and diammonium phosphate as fire retardants. Forest Fire Res. Conf. Woodlands Sect. Rpt. Canad. Pulp & Paper Assoc., pp. 19-21. Also in Pulp & Paper Mag. Canada 62(7): 152, 157-158.

(A summary of results of recent tests of firefighting chemicals in the United States and discussion of potential developments.)

Cramer, Owen P.
Adjustment of relative humidity and temperature for differences in elevation. Pac. NW. Forest & Range Expt. Sta. Res. Paper 43, 21 pp., illus.

(Explains variation of humidity and temperature in mountainous terrain and provides chart aids for adjusting known humidities and temperatures to other elevations. Includes a method for predicting afternoon temperature and humidity at valley stations from morning observations at peak stations.)

Cramer, Owen P.
Predicting moisture content of fuel-moisture-indicator sticks in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta. Res. Paper 41, 17 pp., illus.
(Presents graphs for predicting 4:30 p.m. moisture content of 1/4-inch, fuel-moisture-indicator sticks from predicted relative humidity and current observed fuel moisture. Fuel moisture can be approximated for any station for which relative humidity is known.)

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The 1961 fire season in the Pacific Northwest. Pac. NW. Forest & Range Expt. Sta., 22 pp., illus.
(Analysis of fire season severity using three indexes of weather factors closely related to forest fire behavior. Fire occurrence figures are given, and for west-side areas are compared with the occurrence that would have been expected with similar weather during 13- and 17-year base periods ending in 1956.)

_____ and Graham, Howard E.
Forest fire weather in eastern Oregon and central Washington in 1960. Pac. NW. Forest & Range Expt. Sta. Res. Note 200, 8 pp.
(This first analysis of fire-weather severity on the east side found the 1960 season among the most severe since 1939 in eastern Oregon and more severe than normal in eastern Washington.)

_____ and Lynott, Robert E.
Cross-section analysis in the study of windflow over mountainous terrain. Amer. Met. Soc. Bul. 42: 693-702, illus.
(Explains the application of potential temperature analysis with atmospheric cross sections to the study of surface winds in mountainous terrain. Examples of cross-section analysis across the Oregon Coast Ranges are given.)

Insects

Buckhorn, W. J., and Orr, P. W.
Forest insect conditions in the Pacific Northwest during 1960. Pac. NW. Forest & Range Expt. Sta., 40 pp., illus.
(A detailed annual summary of the status of destructive insects in the forests of Oregon and Washington.)

Furniss, R. L.
Report on European pine shoot moth. Wash. State Forestry Conf. Proc. 1960: 41-45.
(A report on the status of the shoot moth in Oregon and Washington and of efforts to prevent its spread to natural stands of ponderosa pine.)

Johnson, Norman E., Wright, K. H., and Orr, P. W.
Attack and brood survival by the Douglas-fir beetle in four types of windthrown trees in western Washington. Weyerhaeuser Co. Forestry Res. Note 40, 13 pp., illus.
(Broods of beetles were produced in the following order of abundance from the four types of windthrow studied: shaded second growth, shaded old growth, exposed old growth, and exposed second growth. Accordingly, salvage priorities should follow this order.)

Thomas, G. M., and Wright, K. H.
Silver fir beetles. U.S. Dept. Agr. Forest Pest Leaflet 60, 7 pp., illus.
(A practical leaflet for field use, illustrating the two species of beetles, describing their habits and the damage they cause, and recommending control measures.)

Whiteside, J. M., and Carolin, V. M.
Spruce budworm in the western United States. U.S. Dept. Agr. Forest Pest Leaflet 53, 8 pp., illus.
(A practical leaflet for field use, illustrating life stages of the spruce budworm, describing its habits and the damage it causes, and giving measures for control.)

FOREST PRODUCTS UTILIZATION

Clarke, E. H.
Ponderosa pine lumber recovery in north-central Washington. Pac. NW. Forest & Range Expt. Sta. Res. Note 211, 19 pp., illus.
(Presents results of a study to determine lumber-grade yield and volume recovery from ponderosa pine logs from the upper Entiat River drainage area of the Wenatchee National Forest.)

Grantham, John B.
Wood density is a most useful index of wood quality. Wash. State Forestry Conf. Proc. 1960: 49-53.
(Wood density, which can be measured rather simply, relates well to the strength properties of wood and thus provides a useful index to its structural quality.)

Knauss, A. C., and Clarke, E. H.
Seasoning and surfacing degrade in kiln-drying Douglas-fir in eastern Washington. Pac. NW. Forest & Range Expt. Sta. Res. Note 209, 10 pp.
(Presents results of a study to determine the degrade (loss in volume and grade) of Douglas-fir lumber when kiln-dried and surfaced in accordance with commercial practice in eastern Washington, and indicates where improvement in equipment and practice might be profitable.)

_____ and Clarke, E. H.
Seasoning and surfacing degrade in kiln-drying ponderosa pine in eastern Washington. Pac. NW. Forest & Range Expt. Sta. Res. Note 205, 12 pp.
(Presents results of a study to determine loss in volume and grade of ponderosa pine lumber when kiln-dried and surfaced in accordance with commercial practice. Points out the major seasoning and surfacing defects that developed and suggests improvements in equipment and practice that might be profitable.)

_____ and Clarke, E. H.
Seasoning and surfacing degrade in kiln-drying western hemlock in western Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 207, 11 pp.
(Evaluates the effect of seasoning and surfacing defects on grade recovery and loss in sales value for western hemlock lumber kiln-dried and surfaced by commercial practice, and suggests where improvements might be profitable.)

RANGE MANAGEMENT

Garrison, G. A.
Recovery of ponderosa pine range in eastern Oregon and eastern Washington by seventh year after logging. Soc. Amer. Foresters Proc. 1960: 137-139, illus.
(Describes the recovery of range vegetation by the end of the seventh year following logging of ponderosa pine ranges, and points out the need for management practices that will accelerate restoration of understory vegetation after timber harvest.)

Kinsinger, Floyd E., and Strickler, Gerald S.
Correlation of production with growth and ground cover of whitesage. Jour. Range Mangt. 14: 274-278, illus.
(Summarizes 3 years of study, and shows how whitesage production for the growing season in Nevada can be predicted from growth measurements made in April.)

McConnell, Burt R.
Notes on some rooting characteristics of antelope bitterbrush. Pac. NW. Forest & Range Expt. Sta. Res. Note 204, 5 pp., illus.
(Describes two types of rooting systems of antelope bitterbrush in central Washington and discusses adaptive characteristics for growth on droughty sites.)

Skovlin, Jon M.
A study of the relative utilization of important forage plants on summer cattle range in the central Blue Mountains. Jour. Range Mangt. 14: 174-175.
(Summarizes a study of the relative seasonal utilization of important forage species grazed by cattle on bunchgrass ranges in eastern Oregon.)

Strickler, Gerald S.
A grid method for obtaining loop readings on small plots. Jour. Range Mangt. 14: 261-263, illus.
(Describes a method, and equipment needed, for obtaining 3/4-inch loop readings on plots of different size, shape, and distribution.)

Vegetation and soil condition changes on a subalpine grassland in eastern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Paper 40, 46 pp., illus.
(Reports the results of an extensive comparison of density changes between 1938 and 1957 on high-altitude sheep ranges in the Wallowa Mountains in eastern Oregon. Marked improvement in range condition was noted under improved range management.)

WATERSHED MANAGEMENT

Bishop, Daniel M.
Soil moisture depletion in three lodgepole pine stands in northeastern Oregon. Pac. NW. Forest & Range Expt. Sta. Res. Note 213, 2 pp., illus.
(A 1-year study in Oregon's Blue Mountains indicating that substantial amounts of soil moisture are utilized during the growing season in lodgepole pine stands on pumicite soils.)

GENERAL

Adams, Thomas C.
Book review of "Western Forest Industry--An Economic Outlook," by John A. Guthrie and George R. Armstrong. Land Econ. 37: 285-287.

(Points up value of this study in defining the 11 western States as an economic unit, broader in concept than the individual regions which comprise it. The authors suggest that the cut on public forests may be increased during the next 40 years without jeopardizing sustained yield. This review criticizes techniques used in economic projections.)

Bernstein, David A.
An evaluation of lithographed forest stereograms. Pac. NW. Forest & Range Expt. Sta. Res. Note 212, 5 pp., illus.

(Lithographed forest stereograms can replace photographic prints for certain training and illustrative purposes at greatly reduced costs.)

Bruce, David
Book review of "Forest Fire: Control and Use," by Kenneth P. Davis. Ecol. 42: 609-610.

(An evaluation of the usefulness to ecologists of a textbook on fire control.)

Carolin, V. M., Jr.
Book review of "Forest and Shade Tree Entomology," by Roger F. Anderson. Forest Sci. 7: 129.

(Reviews a new text on forest entomology which covers the basic aspects of entomology and the rudiments of forest insect survey and control, and provides keys for identification and biological information on many forest insect pests.)

Costello, David F.
Book review of "The Meaning of Wilderness to Science," edited by David Brower. Jour. Range Mangt. 14: 163.

(Reviews the printed proceedings of the Sixth Biennial Wilderness Conference. The purpose of the conference was to explore wilderness values in relation to science.

Cowlin, R. W.
Progress of research in the Pacific Northwest. 10th Pac. Sci. Cong. Papers 1961, 3 pp.

(A summary review of significant forest research accomplishments in the Pacific Northwest since organized research activities commenced in this region about 40 years ago.)

Fedkiw, John.
Undergraduate education. Chapter 10. In Essays on the growth and development of New York State's College of Forestry 1911-1961, pp. 175-202, illus. Syracuse: Alumni Assoc. State Univ. Col. Forestry Syracuse Univ.

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